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THE AMERICAN JOURNAL OF SCIENCE.

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FOURTH SERIES.

VOL. IX—[WHOLE NUMBER, CLIX.]

No. 49.—JANUARY, 1900.

NEW HAVEN, CONNECTICUT.
1900.

TUTTLE, MOREHOUSE & TAYLOR, PRINTERS, 125 TEMPLE STREET.

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Cobalt,	.52	"
Phosphorus,	.20	"
Sulphur,	.06	"
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THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

ART. I.—*On the Products of the Explosion of Acetylene;* by W. G. MIXTER.

[Contributions from the Sheffield Laboratory of Yale University.]

THE study of the explosion of acetylene has been continued in order to obtain facts for or against the hypothesis advanced by the writer,* that a sufficient frequency of molecular impacts is requisite to secure spread of explosive change throughout a gas. For this purpose experiments were made with acetylene at high temperatures in tubes such as shown in fig. 1, in which the part *c* is about 20^{cm} long and 11 to 15^{mm} internal diameter. The tubes were filled at common temperature and atmospheric pressure by displacing the air with a current of dry acetylene, mercury serving as a trap in the bends *a* and *b*. Before sealing, the acetylene was blown out of the open ends, as the carbon separating from the gas when heated interferes with closing the tube. The mercury in *b* was shaken into *a* and the apparatus was hung in a Victor Meyer furnace so as to heat all of it below *a*. A standard thermometer was also hung in the furnace with its bulb near the middle of *c*. The reading of the thermometer was not corrected for the thread of mercury out of the furnace, as it accorded fairly with the temperature given by an air thermometer. The temperatures stated are very likely subject to a constant error of several degrees, but the differences in temperature are sufficiently accurate for the work. When the temperature was constant for some minutes strong sparks were passed for an instant between

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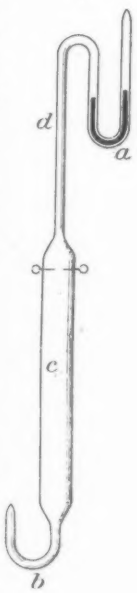


* This Journal, vii, 323, 1899.

the electrodes. The flash at the time of the puff or explosion was reflected from the upper part of *d* and the increased pressure was indicated by the change in the position of the mercury in *a*. In no instance was the explosion violent, nor did the decomposition of the acetylene extend into the narrow tubes. The hydrogen remaining after absorbing acetylene with ammoniacal cuprous chloride was the measure of the acetylene decomposed. The difference between the volume of acetylene taken and the volume of the gas after explosion was considered as the measure of the acetylene which had been converted into condensation products. The results are given in parts of 100 volumes of the gas taken.

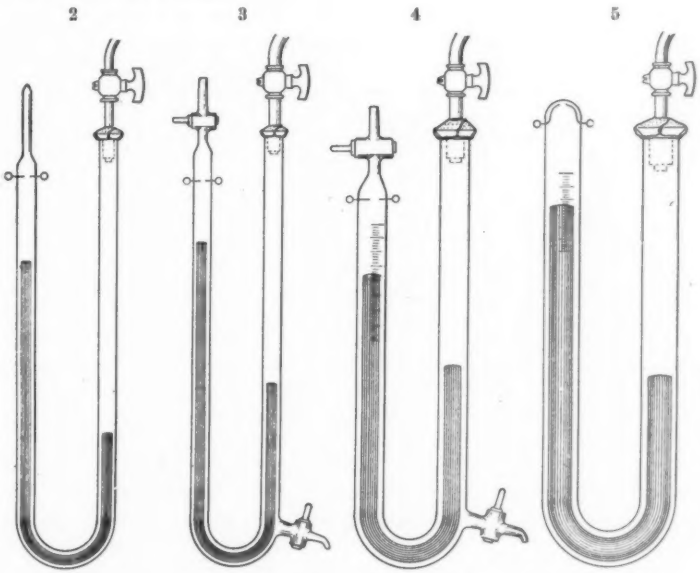
No. of Exp.	Diameter of tube.	Temperature before sparking.	Acetylene decomposed.	Acetylene condensed.	Acetylene in residual gas.
1	12mm	325°	7		
2	"	325°	8		
3	"	330°	25		
4	"	335°	30		
5	13mm	340°	50		
6	12mm	345°	56		
7	"	345°	50		
8	"	356°	80		
9	11mm	365°	50		
10	"	above 365°	50	20	30
11	15mm	350°	70	6	24
12	"	above 400°?	50	10	40
13	"	347°	61	17	22
14	"	447°	50	20	30
15	"	478°	10?	40	50

At the highest temperatures given in the above table acetylene forms condensation products, but too slowly to interfere with the results. When the gas was heated for an hour and a half to the highest temperature attainable by the furnace, probably about 500°, a black coating formed on the platinum wires in the tube and a starry deposit on the glass, and the gas remaining was two-thirds the original volume. The temperatures in the last three tests were obtained with an air thermometer.* In Experiment 15 there was no explosion; perhaps the

* The air thermometer was made about the same capacity and out of the same piece of glass tubing as the apparatus holding the acetylene. Its capacity in grams of water was found and then it was filled with dry air, fastened to the acetylene tube and both tubes were hung in the furnace. Just before sparks were passed through the acetylene the air thermometer was sealed. When cold it was opened under water of known temperature, closed again, wiped dry and weighed. The data for finding the temperature were the volume and temperature of the air in the tube before and after heating. The temperature of 347° obtained in 13 accorded fairly well with that given by the mercurial thermometer hung in the furnace with the air thermometer.

spark did not pass in the gas. It is probable, however, that sparking caused a change consisting chiefly of polymerization. The appearance of the tubes after explosion suggested that falling and glowing carbon effected part of the change. In order to get evidence of this and also to observe the glow, experiments were made in a tube with stop-cocks at its ends having a diameter of 15^{mm} and a capacity of 80^{cc}. I am indebted to Dr. Boltwood for his kindness and skill in making this tube. It was filled with dry acetylene at a pressure of about 2·3 atmospheres, and was placed upright with the electrodes at the lower end. Experiments 16, 17 and 18 gave 9, 14 and 10 per cent respectively of acetylene in the gas remaining after the explosion. In each case a glow filling 3 or 4^{cm} in length of the tube passed slowly to the top.

Since acetylene was found in the gas after explosion in all of the foregoing experiments, it seemed best to make more tests of the gas when under pressure. For this purpose the next series of experiments were made in the U-tubes shown in figs. 2, 3, 4 and 5.



No. 2 had an internal diameter of 10^{mm} and was filled with about 15^{cc} of dry acetylene; 3 a diameter of 11^{mm} and 30^{cc} of gas; 4 was a graduated eudiometer 17^{mm} in diameter and was filled with 60 to 80^{cc} of gas. No. 5 was also graduated and was

20^{mm} in diameter. It differed from the others in having the ends of the electrodes almost touching the upper inner surface of the glass. The experiments were made at the temperature of the room. The results are in volumes per hundred of gas taken.

No. of Exp.	Diam. U-tube.	Pressure.	Acetylene decomposed.	Acetylene condensed.	Acetylene in residual gas.
19	17^{mm}	2·6 atmos.	47·2	6·2	46·6
20	10^{mm}	3· "	50·	10·	40·
21	10^{mm}	3· "	79·	5·	16·
22	11^{mm}	3· "	74·	13·	13·
23	17^{mm}	3· "		5·8	
24	11^{mm}	3· "	60·	10·	30·
25	17^{mm}	3· "	40·	5·	55·
26	10^{mm}	3· "			6.25
27	20^{mm}	3· "	76·2	19·	4·8
28	20^{mm}	3· "	74·3	19·2	6·5

In 19, 21, 22 and 23 the explosion was prompt and violent, while in 24 and 25 it was slow. The character of the explosion in No. 20 was not noted. The volume of the exploding gas in No. 23 increased three-fold. Fearing an accident, I unfortunately did not view Nos. 27 and 28, in which the decomposition was not of an explosive character, for in 27 the volume of the gas was increased only 1/5 by the heat. Moreover, in these cases there was no dull thump, as there was when the gas was exploded in the other eudiometers. In both 27 and 28, where the gas was subjected to sparks at the surface of the glass in the upper end of the eudiometer, the carbon was deposited on the sides of the tube in brilliant black rings shading into dull black, showing that there was a peculiar wave motion in the decomposition. These rings were about 2^{cm} from center to center, or about the diameter of the tube.

It has commonly been considered that acetylene, when exploded, separates completely into carbon and hydrogen. Berthellot and Vieille* state in substance that when exploded under pressure it is decomposed into carbon and hydrogen gas having the volume of the acetylene taken, and Berthellot and Chatelier,† in their paper on the velocity of explosion of acetylene, discuss the phenomenon on the assumption that the products of the explosion are solid carbon and gaseous hydrogen. Doubtless these constituted most of the product at the high pressures, 5 to 30 atmospheres, they used. My experiments thus far given show conclusively that acetylene is not completely decomposed when exploded at 3 atmospheres in glass tubes 20^{mm} in diameter or narrower. Experiments were next conducted in a

* Comptes Rendus, cxxiii, 523. † Comptes Rendus, cxxix, 427.

rough bomb made of steam fittings. About 6 per cent of acetylene was found in the gas remaining after an explosion under a pressure of 5 atmospheres. The apparatus was unsatisfactory, as it had three small metal tubes in which perhaps the acetylene was under the same conditions as it was in the glass eudiometers. To avoid these objections, another bomb, fig. 6, was made from two cylinders such as are used to hold liquid nitrous oxide. It is essentially an iron cylinder 7·5^{cm} in diameter, having a capacity of one liter. All of the metallic surface of

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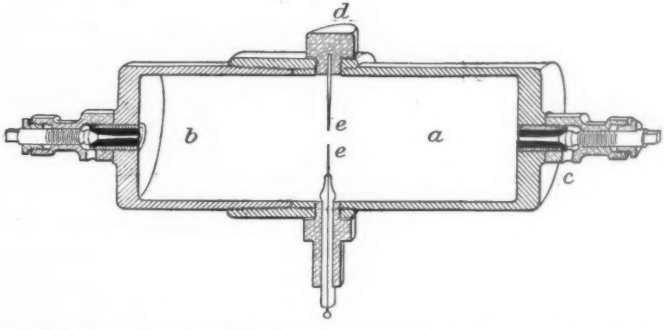

the inside was smooth and bright. The part *a* was fastened permanently in the coupling and the part *b* was connected by a screw made gas-tight with wax which did not reach the inner ends of *a* and *b*. These ends fitted closely. The electrodes *ee* were in the middle of the bomb, one was insulated and the other was connected with the metal of the bomb. It was filled by means of a pump with acetylene from a gas holder. The gas was dried by passing it through a cylinder filled with a kilo of small stick potash. After the air had been displaced the manometer was connected at *c* and the gas was slowly pumped in until the pressure was in excess of that desired. Then 100^{cc} of the gas from the bomb were passed into a eudiometer and treated with ammoniacal cuprous chloride to determine its purity. The manometer was disconnected before exploding, since it was shattered by the first explosion in the smaller bomb. The explosion was effected by sparks from a coil giving a 4^{cm} spark in air. To ensure brief sparking the primary circuit was closed for an instant only. The explosion was noiseless, but the result was evident from the increased temperature of the bomb.

Experiment 29.—Gas, 99 per cent of acetylene; pressure, 3 atmospheres. Two determinations of acetylene gave 4 and 4·1 per cent. The carbon was quite bulky, filling about half of

the bomb, and adhering rather firmly to the metal. A faint odor of hydrocyanic acid was perceived on opening the bomb, but no satisfactory reaction was obtained for it. The wooden insulator was slightly browned. It is not probable that any acetylene was formed from the wood, as it yields, when heated, chiefly hydrogen and methane.

Experiment 30.—Gas, 96 per cent of acetylene; pressure, 3 atmospheres; 4·1 per cent of acetylene was found in the gas after the explosion. The odor of hydrocyanic acid was strong. The residual gas was passed through a solution of potassium hydroxide free from cyanide. To a portion of the solution ferrous-ferric sulphate was added, and the mixture was warmed and then cooled. On adding to it an excess of hydrochloric acid an abundant precipitate of Prussian blue formed. If the gas contained cyanogen, this would have formed with potassium hydroxide, cyanide and cyanate. The latter is converted into an ammonium salt on adding an acid. A test did not yield any ammonia, but the negative result is not in this one test to be regarded as proof of the absence of cyanogen.

In the explosions in the U-tubes the gas expanded, often to twice or thrice the original volume, thus allowing the products of the explosion to cool more rapidly than when the volume is not changed at the instant of the explosion. In order to imitate to some extent the conditions in the explosions in the U-tubes, the plug of the bomb was replaced by the check valve, fig. 7. This was designed to close the opening after the gas ceased to escape and thus prevent air from entering the bomb. It was also sealed promptly with wax. A small platinum wire for an electrode was fastened in the opening *a* with a bit of pyroxylene and a few milligrams of beeswax was melted into it. The 4^{mm} hole in the last experiment was too large to close in this way, hence it was plugged with a bit of glass tubing holding the electrode. No wax was exposed to the gases in the bomb. The glass broke promptly when the explosion occurred. In Experiments 31 and 32 an insulator made of glazed clay pipe stem was used. It was cracked by two explosions so that it ceased to insulate. In the remaining experiments glass insulators made of heavy barometer tubing were used. The portion of the glass in the bomb was cracked as if dipped when hot into water.

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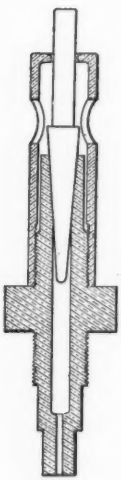

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Experiment 31.—Gas, 99 per cent of acetylene; pressure, 3 atmospheres; hole, 1·1^{mm} in diameter. Gas and carbon escaped

for perhaps three to five seconds and burned with a luminous but smokeless flame. Two estimations of acetylene in the residual gas gave respectively 5·2 and 5·4 per cent.

Experiments 32 and 33.—These were made as nearly as possible under the same conditions as 31. The residual gas in 32 yielded 6·6 and 7 per cent of acetylene, and that in 33 4 per cent of acetylene.

Experiment 34.—Gas, 98 per cent of acetylene; pressure 3 atmospheres; hole $2{\cdot}1^{mm}$ in diameter. The residual gas yielded 5·7 and 5·5 per cent of acetylene.

Experiment 35.—Pressure 3 atmospheres; hole 4^{mm} in diameter. Each of two estimations of acetylene in residual gas gave 4·2 per cent.

Berthellot and Vieille* found in their experiments that the pressure in an explosion is about eleven times the initial pressure, corresponding fairly with the pressure of the gas at the calculated temperature of 2790° C. In the explosion in the bomb above described, the temperature was very high, as platinum wire was repeatedly melted and made brittle. But a wire in contact with the pipe-stem insulator was not melted. The shattering of the glass insulators was undoubtedly due to the intense heat, for in no instance was a glass eudiometer cracked, the quantity of heat not being sufficient to affect the glass. Berthellot and Chatalier† found the velocity of explosion in narrow tubes at pressures from 5 to 30 atmospheres to be 1000 to 1600 meters per second. In my experiments at 3 atmospheres in glass tubes the velocity was low in some cases.

The experiments 1 to 15 were made with an equal number of molecules in a unit of space. At 325° the decomposition did not extend throughout the gas, although here the energy of the system was greater than that containing twice as many molecules at 0° in the same space—a condition in which decomposition will propagate itself. In the cool and denser gas the molecular impacts are more frequent than in the hot gas. At temperatures above 325° the decomposition was self propagating. Here we have impacts of sufficient frequency to cause explosion. It is highly probable that acetylene at 400° and atmospheric pressure will not explode. The results at high temperatures present the striking fact that the amount of acetylene decomposed, or rather the hydrogen remaining, is fairly constant in a range of 100°, that is, from 350° to 450°. The products at high temperatures and in the U-tube tests were essentially alike, consisting of carbon and hydrogen, condensation products and acetylene. The wave-like character observed in 27 and 28, suggests that the marked variation in the results ob-

* Loc. cit. † Loc. cit.

tained in U-tubes was due to differences in the way the sparks started the decomposition. The acetylene in the residual gas in the experiments in the tubes when the explosions were violent was either a portion that escaped decomposition because of the cooling at the sides of the tubes, or it was formed from carbon and hydrogen at high temperatures. The experiments with the bomb were more satisfactory as regards uniformity of results than those made in the smaller pieces of apparatus. The escape of gas at the time of an explosion in the bomb did not increase the amount of acetylene left. Perhaps the expansion was not sufficiently rapid. The presence of acetylene to the extent of 4 to 6 per cent in the gaseous product of explosions in the bomb must be regarded either as a part of the original gas which escaped decomposition, or it was acetylene formed synthetically. It hardly seems probable that any gas at the time of the explosion remained below the temperature requisite for decomposition when the mean temperature was far higher and at the surface of a glass insulator was sufficient to crack it; moreover, the carbon separated remains incandescent for a perceptible time and must effect decomposition. It would seem then that the acetylene in the residual gas is not part of the original gas but is formed from carbon and hydrogen after the explosion when the carbon is either in the gaseous state or exists in molecules containing but few atoms and capable of uniting with the hydrogen. This view is supported by the fact that acetylene is formed in the voltaic arc. The proof given of the formation of an endothermic compound of nitrogen and carbon, not originally in the apparatus, also affords a strong support to this view of the production of acetylene by synthesis.

It is the intention of the writer to continue the work with acetylene under different pressures than three atmospheres, and to make experiments with mixtures of acetylene and nitrogen.

ART. II.—*Note on the Glaciation of Central Idaho;* by GEORGE H. STONE.

CENTRAL IDAHO is rugged and mountainous, a succession of dark green and blue forested ranges. The rocks are mostly granites, schists, and quartzites, which in different regions vary greatly in capacity to withstand weathering and erosion. The larger streams flow in deep, cañon-like valleys, which broaden into plains in places where the rocks are easily disintegrated. Several of the principal watersheds consist of rolling plateaus but little dissected by erosion. They appear to be remains of what was once a large plain-like plateau and have an elevation of 7,000 to 8,000 feet above the sea. Approaching the larger rivers, we find the slopes becoming steeper and the whole country deeply dissected and accentuated by erosion, until we reach the principal rivers, the Snake and the Salmon, flowing in valleys of erosion 6,000 or more feet in depth. A few ranges appear to have been raised above the adjacent parts and are mountains of upheaval. During glacial time the relief forms of the land were substantially the same as at present. All of the large ranges and many of the peaks now having an elevation of about 6,000 feet shows signs of extinct glaciers. The geographical position of Idaho with respect both to the Pacific Ocean and the vast Canadian areas of extreme winter cold, is favorable to a large snowfall, both now and at all times since the rise of the continent above the ocean. The following personal observations were made by the writer during a recent reconnoissance.

The mountain ranges that form the watersheds between the Boise, Payette, and Salmon rivers formed the gathering ground of numerous local glaciers. Those which flowed south and west down the valleys of the Boise and the Payette ended at not far from 5,000 feet elevation. Those flowing north and east down the valleys of the South and Middle Forks of the Salmon reached a somewhat lower elevation, but none of them reached so low an altitude as the main Salmon river, which in this part of its course has an elevation of less than 1,000 feet. From the east and west divide between the Salmon and the Clearwater, local glaciers flowed south into the gorge of the Salmon, but none appear to have reached that river. From this same divide glaciers flowed north to the South Fork of the Clearwater. The broad valleys of both the South and Middle Forks of the Clearwater were covered by valley glaciers, i. e., the local glaciers that originated in the Bitter Root range and the higher ranges that form the rims of these basins united to

form a confluent ice sheet in each valley. The ice covered all the lower hills in the central parts of each drainage basin and flowed westward up and over these hills, and finally narrowed into the deep cañons which form the channels of the South and Middle Forks at and below 3,500 feet elevation. The great ice sheet which at one time covered British Columbia east of the Cascade range, and which had a southward flow during the time of deepest ice, did not reach so far south as the Clearwater valley. The valley ice sheets of the South and Middle Forks of the Clearwater closely correspond to what Russell has termed the Piedmont type of glaciers.

The signs of glaciation in all the region in question are distinct and unmistakable. Morainal ridges and terraces are common in the higher valleys, but in general the ice appears to have retreated at so uniform a rate as to leave most of the morainal matter in the form of a diffused sheet. There are numerous lakes held in by morainal dams, as the Lower Payette Lake and Trout Lake on Lake Creek, a few miles southeast from Buffalo Hump. Only in few regions do the rocks withstand weathering so as to preserve the glacial scratches. At Buffalo Hump the granites, schists, and quartzites equal or surpass the best Maine and New Hampshire granite in capacity to withstand the elements, and the rock is beautifully smoothed and scored to within about thirty feet below the summit of the Hump. The glaciated stones are in general so smooth and rounded at the angles that they have often been mistaken for water-rolled stones, distinct scratches being rare. In the regions where the granite and schists weather readily, the morainal matter consists of smoothed stones of quartzite or other resistant rocks, scattered through angular sand and gravel resulting from the disintegration of the fragments of granite and schists. In many cases the glaciated stones are remarkably round and smooth almost to the tops of ridges from which the ice flowed in opposite directions, as on Buffalo Hump and on the much dissected ridge dividing Boise Basin from the valley of the South Fork of the Payette. Much, perhaps most of the morainal matter was sub-glacial, which accounts for the great attrition it received.

The water-transported deposits of the glaciers of this region were mostly "overwash," i. e., were sediments poured out of ice channels into open ground beyond the front of the ice. These are sometimes plain-like, as at Warren Meadows; at other times they take the form of terraces in the narrow valleys. The overwashed gravels have often been regarded as lake beds, especially when they expand into broad plains. Not seldom sediments were deposited in the beds of streams and lakes between the margin of the ice and adjacent hills. The Payette

formation of Lindgren's map of Boise Basin is, at Placerville at least, of glacial age and glacial origin.

A short distance south of Elk City is a series of glacial gravels deserving special study. A gravel plain one-eighth of a mile to about a fourth of a mile in breadth, and in places eighty feet deep, leaves the valley of Red Horse river, and extends seven miles westward, first going obliquely over hills more than 100 feet high; then for two miles is on the top of the hills immediately adjoining the American river on the south; then crosses that stream obliquely, ascends a hill; then crosses the valley of Elk Creek nearly at right angles and ascends another hill to Buffalo Hill placer. The American Hill placer is part of this gravel system. I did not follow the course of this interesting gravel system east or west of the points named, but it probably can be traced for miles in both directions. The direction of transportation was westward. Above the point where this gravel system crosses the American river, the gravel of that stream is much less worn and rounded than below that point. The materials of this gravel plain are very round and smoothed gravel, cobbles, bowlderets and even some bowlders, and they have afforded millions in gold. On the hills between Red Horse and American rivers the placer miners have washed away the overlying gravel. The rock beneath the gravel is very much smoothed and polished, but is very uneven, containing many rounded depressions, bowls and pot holes up to five feet in depth. Evidently here was a broad river that flowed up and over hills and valleys. That it disregarded the surface forms of the land proves that it was enclosed between walls of ice. The stratification is not arched in cross section like that of the osar proper, but is horizontal, like the deposit I have elsewhere described as the osar plains of Maine.

An interesting feature of this gravel system is the fact that it contains multitudes of fragments of cedar wood, mostly at certain horizons at considerable height above the bottom of the gravel. Some of these pieces retain their original state and will burn after being dried; others have been changed into an imperfect lignite, while the greater number have been partly or wholly silicified. The growth rings prove they were mostly derived from trees of considerable size. I saw no pieces of a whole trunk; all had been split and broken across into pieces of all sizes up to twelve inches in thickness and up to eight feet in length. All the pieces have been smoothed at the sides and well rounded at the ends and angles.

The facts prove that here was once a river of water flowing through a stagnant glacier that had become covered with a forest growth like many of the Alaskan glaciers to-day. No

matter whether the glacial river flowed in a sub-glacial, or englacial, or in a superficial channel during the time of rapid flow of the ice, it must have flowed in an open ice cañon during the period of stagnation. Into this cañon trees that were growing on the glacier fell as they were undermined by the melting of the ice walls of the channel. The fact that the trunks were broken into so small fragments indicates more force than is usual in the case of ordinary stream channels. Probably the motion of the ice helped to break up the trees, assisted by ice and timber dams or gorges.

The occurrence of wood in the esker gravels of Idaho suggests a comparison of that region with New England.

In New England there were many level regions, especially in Maine to the north of east-and-west ranges of hills, where the ice would naturally become stagnant during the final melting and retreat of the great ice sheet. The Idaho facts suggest that if vegetation crowded close on the front of the New England ice sheet, the stagnant ice ought there to become forested as in Idaho. In this case we ought to find pieces of wood in the broad osar plains of Maine and in such portions of the valley drift as were glacial overwash. No wood or other land organic remains have yet been found in these deposits in Maine, though Emerson has found in the Connecticut valley vegetable remains in sediments of glacial age. The absence of wood from the eskers and valley drift of all of northern and northeastern New England can fairly be urged as proving that forests did not press closely on the front of the retreating ice sheet in that region. This is supported by another consideration, viz., that at the time of maximum glaciation the ice confronted the sea along the whole New England coast. When the ice retreated, vegetation would have to advance a long way eastward as well as northward in order to reach Maine from New Jersey, the nearest land then covered by vegetation, unless possibly we except Nova Scotia. The above considerations make it probable that the stagnant marginal portions of the retreating New England ice sheet did not become forested, at least toward the northeast.

The large valley ice sheets or Piedmont glaciers of north-central Idaho formed a type intermediate in character between the more strictly local glaciers found farther south, and the great confluent ice sheet of British Columbia.

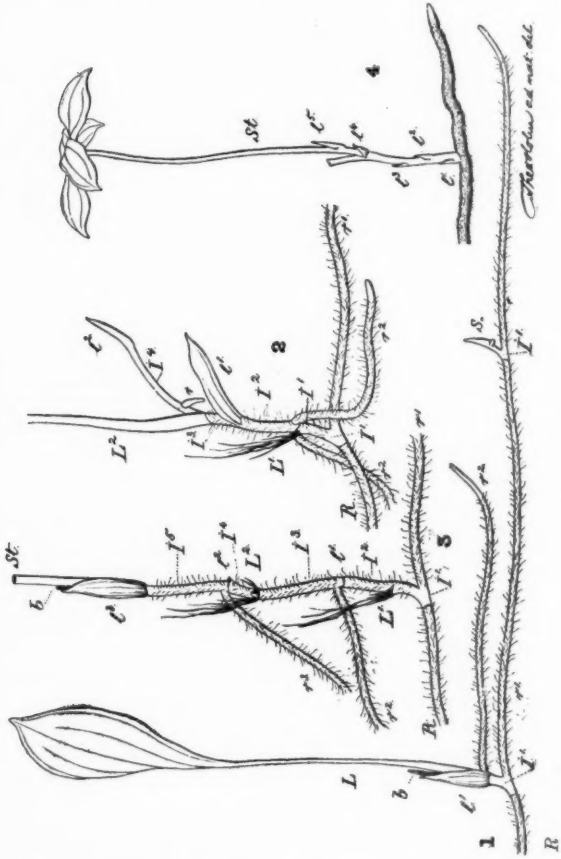
November, 1899.

ART. III.—*Pogonia ophioglossoides* Nutt. *A morphological and anatomical study;* by THEO. HOLM. (With four figures.)

THE genus *Pogonia* is represented in the Atlantic States by five species, which according to Bentham and Hooker are to be classified in no less than three sections, viz: *Eupogonia* (*P. ophioglossoides* Nutt. and *P. divaricata* R. Br.), *Triphora* (*P. pendula* Lindl.) and *Codonorchis* (*P. verticillata* Nutt. and *P. affinis* Aust.). It deserves notice that these sections are established rather upon the vegetative than upon the floral characters, and Bentham and Hooker have pointed out, that the stem has but one leaf, one bract and one flower in *Eupogonia*, while in *Triphora* there are several leaves, bracts and flowers; finally in *Codonorchis* the stem bears a whorl of three to six leaves and a single flower or seldom two as in *P. affinis*. Besides these vegetative characters the floral ones offer several important points useful to the classification of these singular plants, thus Nuttall and Rafinesque separated their genera *Triphora* (Nutt.), *Isotria* and *Odonectis* (Raf.) from *Pogonia* proper, the two last being, however, identical with *Codonorchis* Lindl. It must be admitted that the general habit of these plants is very different, and even if no further distinctions were to be drawn than those recorded by Bentham and Hooker, it would seem very natural to consider these species as representing three well defined genera. However if we examine the parts underground, we find a few additional characters, which are no less important to the classification of the species.

The roots are generally described as "thick fibers," "a cluster of fibers" or "oblong tubers" and Willdenow described his *Arethusa pendula* as possessing a tuberous root; this plant is Nuttall's *Triphora pendula*, and it is, also, the "Helleborine mariana, flore pendulo purpureo trianthophoros" of Plukenet. But otherwise the systematic authors give no further details in regard to the root-system and no information whatever concerning the rhizome. Our species of *Pogonia* are all terrestrial and, excepting *P. pendula*, possess a slender rhizome, which is relatively short, vertical or ascending and densely covered with long, unicellular hairs. Underground stems with hairs are rare, but are known in other genera of the *Orchideæ*, for instance *Listera*, *Goodyera* and the rootless *Corallorhiza*. In examining a rhizome of *Pogonia ophioglossoides* (fig. 3) we find it consists of five distinct internodes (i^1-i^5), the uppermost (i^5) passing into a flower-bearing stem (St.). The rhizome is vertical, bearing rudiments of two green leaves (L^1-L^2) and two scale-like and membranaceous (l^1-l^2), while a third scale-like one is still fresh and surrounds the base of the flower-bearing

stem (l^3). Characteristic of the rhizome is the monopodial growth, which ceases, however, when the flower-bearing stem dies away. After that time it becomes a sympodium, as the axillary bud (*b*) will develop and continue the growth of the rhizome. This is, however, not the only bud, which is visible



at the present stage, since another one, though dormant, is developed in the axil of the leaf L^2. It is evident that this dormant bud would have grown out into a branch, if the upper part of the rhizome might have become injured, but not otherwise. The same mode of growth is, also, to be observed in such specimens, which are yet purely vegetative as the one drawn in fig. 2. In this the green leaf (L^2) and the scale-like

one (l^1) are still fresh and the apex of the rhizome is terminated by a bud, surrounded by the scale-like leaf l^2. There appears thus to be a regular succession of green and scale like leaves, but the most common case is, however, that the first leaf of the root-shoots is scale-like instead of being a green, assimilating one.

In passing to describe the root-system, it may be stated at once, that the main propagation of our plant, *P. ophioglossoides*, seems to take place by means of root-shoots. All the specimens which were collected by the writer in a Sphagnum-swamp near Washington, D. C., were developed from roots, and the same was, also, the case with a number of specimens from a similar locality in Maine, kindly furnished by Mr. M. L. Fernald of the Gray herbarium, Harvard University.

This is the more surprising since, so far, but very few of the *Orchideæ* are known to propagate in this manner, the only ones being: *Neottia Nidus avis* (L), *Cephalanthera rubra* (L), *Epipactis microphylla* (Ehrh.) and *Listera cordata* L., all from Europe; besides that we have, also, observed a similar development of root-shoots in *Pogonia verticillata* (fig. 4). It is very likely that similar cases may be observed in *P. divaricata* and *P. affinis*, but our dried material, the only one being at hand, was not preserved very carefully so as to demonstrate the root-system. It appears as if this formation of root-shoots is confined to such genera, in which no tuberous roots occur, and in which no tuberous or bulbous stem-internodes are developed. We might suppose that several of the other *Orchideæ* really exhibit the same manner of propagation, but only those of which the root-system is similar to that of *Pogonia* or *Neottia*; it is, no doubt, a character common to the species of *Listera*, *Cephalanthera*, *Epipactis*, and perhaps also to *Cypripedium*, at least in some of those roots which run in a horizontal direction close beneath the surface of the ground. Among the dicotyledonous orders many species propagate in this way, and we need only to refer to the long lists of such plants, contributed by Warming and Wittrock.* However, root-shoots may be of very different kind, and Professor Wittrock has proposed three categories in regard to the circumstances under which they may occur and in regard to their importance to the mother-plant: reparative, additional and necessary.† The root-shoots

* For references consult the bibliography appended to this article.

† Reparative root-shoots being such which develop only in cases where the root becomes broken away from the mother-plant, and the mother-shoot thus becomes injured or killed: *Taraxacum*, *Centaurea Scabiosa* and *Bunias orientale* for instance. Additional root-shoots develop, on the contrary, spontaneously upon roots of uninjured specimens, hence forming a more or less important addition to the reproduction of the individual: the majority of plants with root-shoots. Necessary are such as constitute a part of the normal, morphological development of certain plants, e. g. *Pyrola uniflora*, *Monotropa Hypopitys*, *Cirsium arvense*, etc.

of our *Pogonia* belongs to the second of these categories, as they merely serve as additional means of the vegetative propagation of this plant. The development of these shoots in *P. ophioglossoides* is interesting and agrees in all respects with the observations made by Brundin in *Listera cordata* L. The most characteristic is that the shoot develops as terminal at the end of a root, and that a secondary root pushes out from the base of the young shoot and in the same direction as the mother-root, as if it was a continuation of this. It is, moreover, to be noticed that this secondary root repeats the development of another shoot in exactly the same manner as the first. This is readily to be seen in fig. 1, where a small shoot is developed at S, of which the first secondary root continues the direction of the older and bends upwards, terminated by a similar growing-point, in which the character of root suddenly becomes changed to that of a stem. That these root-shoots are not lateral, as it might seem from the first glance, but terminal is furthermore explained by the very distinct cross-line, shown on our figure, where the root-hairs cease and from where a stem-part (i^1) arises, while the first secondary root (r^1) develops from this basal stem-part and grows out horizontally in the same direction exactly as the old root (R). The study of the growing-point itself shows this development still more plainly. The roots of *P. ophioglossoides* are very slender, and those we have described above run immediately in a horizontal direction; most of the other secondary roots, on the contrary, which develop higher up on the shoot (r^2–r^3), in figs. 2 and 3, grow often from the beginning downwards, almost vertically, but change their course gradually into the horizontal direction. None of these roots were observed to develop shoots, and their function is perhaps to absorb nutritive matters, and to support the aërial shoot. The very long, horizontal roots, afford an excellent method of distributing the new individuals to a considerable distance from each other. In regard to *P. verticillata* (fig. 4) the roots develop similar shoots, but these do not appear to be terminal, but lateral; our material, however, was too scant to allow any decisive opinion in this respect.

In comparing the rhizome itself of *P. ophioglossoides* with that of *P. divaricata*, the only variation to be observed is that the internodes of the rhizome in the latter are relatively much shorter, while the roots show a like external structure. A similar very short, but strictly vertical root-stock is, also, to be found in *P. verticillata*, which, however, differs from all the others, only excepting *P. affinis*, in having the aërial leaves arranged in a whorl, besides the very striking difference in the floral structure. In the last species of *Pogonia*, *P. pendula*, we notice a rhizome of very singular structure. This species

possesses a tuberous, underground stem, of which, however, only one internode seems to be swollen, from the apex of which the aërial stem arises. The tuber is oblong, covered with short hairs, and bears only one small, scale-like leaf near the apex, from the axil of which a slender stolon develops and grows out horizontally. In the dried material of this plant, kindly furnished to the writer by Mr. Thomas H. Kearney, the stolon was unfortunately not completely preserved, the apex being broken off. We suppose, however, that the tuber develops at the end of the stolon in the same manner as we have observed in *Medeola*, but the tuber of this plant is composed of several thickened internodes instead of but one as in *P. pendula*. The other parts of the rhizome, the basal internodes of the stem, are vertical, slightly hairy like the stolon and provided with a few secondary roots, slender and very hairy. No root-shoots were found in this species, and we did not expect to find such, since the plant is stoloniferous. As stated by Professor Wittrock (l. c.) no stoloniferous plant has, so far, been observed to develop root-shoots. It seems now from these observations as if *P. ophioglossoides* and *P. divaricata* are closely related species, that they exhibit morphological characters that are very different from those of *P. verticillata* and *P. affinis* on the one side and from *P. pendula* on the other.

While studying the anatomical structure we noticed a few points which may be of some interest for further studies of North American *Orchideæ*. The roots in these species are Mycorrhizæ, and the fungal hyphæ were observed in the epidermis, the hypoderm and in the outer strata of the bark-parenchyma. The endodermis is thin-walled, but in *P. verticillata* there is constantly one, or very seldom even two, quite thick-walled endodermis-cells just outside the leptome. The pericambium is thin-walled and in no instance interrupted by the proto-hadrome vessels; furthermore, the conjunctive tissue is quite thick-walled in *P. verticillata*, but not so in *P. ophioglossoides* and *P. pendula*. The rhizome contains fungal hyphæ, which are located in the epidermis and outer bark, and the epidermis has developed numerous long, unicellular hairs of a structure like those of the roots. No stereome is represented in the rhizome, and a thin-walled endodermis surrounds a circle of mestome-bundles, which are bicollateral, perihadromatic, in *P. verticillata;* there is, furthermore, a central pith of thin-walled cells in *P. pendula* and *P. ophioglossoides*, but of thick-walled [illegible] *P. verticillata*. The tuber of *P. pendula* has a huge bark and pith, and the very small mestome-bundles are arranged in a circle inside a very thin-walled endodermis; the epidermis of the tuber contained hyphæ. The aërial stem of *P. ophioglossoides* and *P. verticillata* is hollow and pos-

sesses a ring of stereome around the mestome-bundles, all of which are collateral and very regularly arranged in a circle. A thin-walled, broken pith occupies the inner part of the central-cylinder.

In considering the leaves, these are vertical in *P. ophioglossoides*, but are kept in a horizontal position in *P. verticillata*; they are, nevertheless, almost isolateral in both species, the mesophyll being of a homogeneous structure throughout the blade; however, the epidermis shows on the upper face in both species to consist of much larger cells than on the lower; moreover, the radial cell-walls of epidermis are straight on the upper, but undulate on the lower surface in *P. ophioglossoides*, while they are undulate on both faces in the other species. The stomata are restricted to the lower surface, and the guard-cells are very prominent in *P. ophioglossoides*, but not so in the other. The mestome-bundles are surrounded by a partly green parenchyma-sheath, and only in *P. ophioglossoides* are supported by a small, thin-walled stereome.

In bringing these facts together there appears to exist even anatomical characters, by which *P. verticillata*, *P. ophioglossoides* and *P. pendula* may be distinguished from each other. And although it was the main object of this article simply to call attention to the presence of root-shoots in *Pogonia*, we naturally felt obliged to examine the systematic position of these species, by which we noticed that not all our *Pogoniæ* are Pogonias in the stricter sense of the word. It would seem more natural indeed to adopt the classification proposed by Bentham and Hooker, to separate *Triphora* and *Codonorchis* from *Pogonia* proper.

Brookland, D. C., October, 1899.

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EXPLANATION OF FIGURES.

FIGURE 1.—*Pogonia ophioglossoides.* Rhizome showing a root-shoot developed from the root R, and a much younger one (S) developed from the root r^1; i^1 = the first internode of the root-shoot; l' = the first scale-like leaf; L = the green leaf; b = the terminal bud of the root-shoot. Natural size.

FIGURE 2.—Same species. A similar vegetative, but older root-shoot; r^1 = the first secondary root of the shoot; r^2 and r^2 = a pair of secondary roots developed from base of second internode; r = the secondary root from fourth internode; i^1-i^4 = the four internodes of the shoot; L^1 = scar with fibers left from the first green leaf; L^2 = petiole of second green leaf; l^1 and l^2 = scale-like leaves. This shoot is developed from apex of root R. Magnified.

FIGURE 3.—Same species. Flower-bearing root-shoot. St. = base of flowering stem; the other letters as above. Magnified.

FIGURE 4.—*Pogonia verticillata.* Vegetative shoot in its second year, developed on a root. St. = the stem, which at its apex bears a whorl of four green leaves. Natural size.

ART. IV.—*On Graftonite, a new Mineral from Grafton, New Hampshire, and its Intergrowth with Triphylite;* by S. L. PENFIELD.

MATERIAL for this investigation was sent to the author for identification by Mr. George L. English of New York, who, on being informed that it was probably a new mineral, took special pains to secure a supply of it, and has given the following information concerning its occurrence: The mineral was found on the south side of Melvin Mountain, about five miles west of the village of Grafton. It was irregularly disseminated through a coarse crystalline mass of quartz and feldspar, probably a pegmatite vein, the feldspar individuals being at times fully four feet long. Associated with the new mineral in the vein were found beryl, black tourmaline, almandine garnet, muscovite and biotite, all crystallized on a rather large scale, especially the beryl. All of the new mineral that could be found was taken from the vein, and the total output consisted of a few crystals and a considerable quantity of irregular fragments. The crystals and also the fragments present a rough, weathered appearance, and, what is unusual and at once very striking, they consist of alternating layers or lamellæ of dark and light material, the lamellæ being less than $0{\cdot}5^{mm}$ in diameter and often exceedingly thin. Both the light and the dark material gave reactions for a phosphate containing iron and manganese as bases. The light material, however, contained only ferrous iron, while the dark reacted chiefly for ferric. The light and dark portions were so nearly alike in specific gravity that they could not be satisfactorily separated by means of the silver-thallium nitrate fusion. The dark portion was found to have a somewhat lower specific gravity than the light, and a product was separated which represented a partial separation of the two minerals and consisted chiefly of the light-colored material. This was analyzed by Mr. W. E. Ford of the Sheffield Laboratory with results which are given beyond. The iron was found by Ford to be both ferrous and ferric, and, since a little of the carefully selected light-colored material gave only the reactions for ferrous iron, it was inferred that the original mineral was undoubtedly a ferrous compound, and that the dark portions were the result of partial decomposition, attended by the oxidation of the iron and manganese. Although the analysis indicated that the mineral was undoubtedly new, the results, owing to the character of the material, were not wholly satisfactory and conclusive, and there was some doubt as to the propriety of giving a new name to the species.

Fortunately for the solution of the problem in hand, among several pounds of material sent by Mr. English, a single fragment, about as large as the end of one's finger, was found, which showed only a very little of the dark, decomposed material. It was undoubtedly the central portion or core of a crystal, the outer portion of which had been oxidized, leaving within a core of fresh unaltered material. Upon careful examination this fresh portion was found to consist of two minerals in alternating layers, and fig. 1, which represents the appearance of a thin section prepared at approximately right angles to the lamination, will give an idea of the arrangement and relative proportions of the two minerals. The white portions, *g*, represent the new mineral, graftonite, which constitutes about two-thirds to three-quarters of the total material. This in the fragment possessed a delicate salmon color, but appeared almost colorless in thin section. The other mineral *t*, which in the figure is represented by the stippled portions, was found to be triphylite. The latter possessed a pale green color as seen in the fragment, but appeared almost colorless in thin section. The exterior of this fragment of fresh material showed in places a darkening, due to the oxidation of the iron and manganese, and the thin section showed, as represented by fig. 1, that the oxidation is confined wholly to the triphylite lamellæ, the new mineral being evidently a more stable material. On breaking up the fragment it was found that the lamellæ separated quite readily, and it was possible to obtain the two minerals practically pure, by careful working, splitting off lamellæ at times almost as thin as a sheet of paper, and examining each particle with a lens. Thus, discarding everything which seemed at all questionable and using all of the available material, 0·546 grams of the new mineral and 0·166 grams of the triphylite were secured. The specific gravity of the graftonite was found to be 3·672. The hardness is 5 and the luster is vitreous to resinous. In appearance it resembles very closely the salmon-colored varieties of lithiophilite. The associated triphylite was found to have a specific gravity of 3·58.

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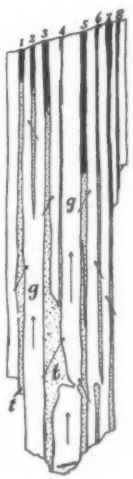


Making complete analyses of the two minerals on the small quantities of available material proved to be a somewhat interesting problem in analytical chemistry, and a brief outline of the method employed is as follows: It was first proved by qualitative tests that the iron was wholly ferrous. All of the

material of each substance being employed, water was first estimated by ignition in a closed tube, as described by the author.* The contents of the tube were then dissolved in hydrochloric acid, the solution evaporated to dryness and the residue was taken up in water and a very little acid. To this solution, heated to boiling, barium hydroxide was added, which precipitated barium phosphate, along with the iron, manganese, magnesium and the bulk of the calcium, leaving the alkalies in solution. After filtering, the barium was separated from the filtrate by means of ammonia and ammonium carbonate, and the alkalies were finally obtained in the form of chlorides. From the very hygroscopic character of the chlorides it was evident that lithium was the prevailing alkali, and, since the quantities were small, it was considered best to weigh the alkalies as sulphates, and subsequently determine the SO_3, thus obtaining data for estimating both the per cent of the alkali oxides, R_2O, and their joint molecular weight. The precipitate produced by barium hydroxide, containing the phosphoric acid and bases, was dissolved in hydrochloric acid, and barium was precipitated by means of sulphuric acid. The barium precipitates, obtained at this stage of the analysis and from the alkali separations, were carefully examined for traces of P_2O_5 and bases. The filtrate from the barium sulphate, containing P_2O_5 and bases, after evaporating to dryness and taking up in a very little acid, was diluted, heated to boiling, precipitated by an excess of sodium carbonate and filtered. The filtrate contained the bulk of the P_2O_5, which was precipitated by magnesia mixture. The precipitate consisted of basic phosphates and carbonates of iron, manganese, magnesium and calcium. The latter was dissolved in a little hydrochloric acid, and the iron in combination with the P_2O_5 was separated by a basic acetate precipitation. After filtering, the precipitate was dissolved in acid, the iron together with the P_2O_5 was precipitated with ammonia, weighed and subsequently the P_2O_5 was separated by means of ammonium molybdate. In the filtrate from the basic acetate precipitate the manganese, magnesium and calcium were estimated by well known methods.

The results of the analyses are given below, together with the analysis made by Mr. Ford on partially purified material.

The analysis of the triphylite, though showing a slight deficiency, compares favorably with the analyses of triphylite from Bodenmais, Bavaria and Norwich, Mass., made by the author† and quoted in Dana's Mineralogy, page 757. The alkali oxide was found to have a molecular weight of almost exactly 30, which is the molecular weight of Li_2O, thus indicating the purity of the oxide.

* This Journal, III, xlviii, p. 31, 1894. † Ibid., III, xvii, p. 226, 1879.

Quantity,	Triphylite. 0·1668 gr.	Graftonite. 0·5462 gr.	Ratio.		Analysis by Ford.
P_2O_5	42·3	41·20	·290		P_2O_5 40·80
FeO	33·4	30·65	·426		Fe_2O_3 10·16
MnO	9·9	17·62	·248	·857	FeO 24·28
MgO	1·3	0·40	·010		MnO 15·38
CaO	0·2	9·23	·165		CaO 7·25
Li_2O	9·2	0·33*	·008		Na_2O 1·15
H_2O	1·7	0·75			K_2O ·14
					H_2O 1·17
	98·0	100·18			100·33

As shown by the analysis of the graftonite, alkalies are practically wanting in the new mineral. The 0·33 per cent recorded as Li_2O was found to have a molecular weight of 44, indicating that the alkali was chiefly lithia, and it is probable that it was derived, for the most part at least, from a slight admixture of triphylite. Since triphylite, however, is a normal phosphate, its presence in very small quantity would have no appreciable effect upon the ratio of P_2O_5 to the total metallic oxides, and hence an amount of triphylite corresponding to 0·33 per cent of alkali oxide has not been deducted from the analysis. The ratio of P_2O_5 : RO, as indicated by the analysis, is ·290 : ·857 = 1 : 2·95, or, approximately, 1 : 3. The formula of graftonite is, therefore, $R_3P_2O_8$, R standing for the bivalent metals, iron, manganese and calcium, which evidently are isomorphous with one another and not present in fixed or definite proportions. In Ford's analysis the considerable amount of Fe_2O_3, which is recorded, indicates that the original mineral has suffered some alteration, attended by oxidation, the amount of oxygen in the 10·16 per cent of Fe_2O_3 in excess of FeO being 1·02 per cent. This oxidation, in all probability, belongs as much to the manganese as to the iron, if not more. If the oxidation is neglected, and the iron considered wholly as FeO, the ratio of P_2O_5 : RO in Ford's analysis becomes 1 : 2·90, or, practically, 1 : 3, as required by a normal phosphate. Moreover, the oxidation has not been attended by any considerable amount of hydration, the amount of water, 1·17 per cent, being small.

From a chemical standpoint graftonite is interesting as being one of the very few anhydrous, normal phosphates thus far observed. Thus, we have xenotime and monazite, normal phosphates of the yttrium and cerium metals, and the minerals of the triphylite group, characterized by containing an alkali metal, as follows: triphylite, $LiFePO_4$; lithiophilite, $LiMnPO_4$; natrophilite, $NaMnPO_4$ and beryllonite, $NaBePO_4$,

* Molecular weight 44, hence containing some Na_2O.

while all other mineral phosphates contain either fluorine or hydroxyl radicals, or water of crystallization.

Before the blowpipe graftonite darkens and fuses at about 2 to a globule which is slightly magnetic. The globule becomes decidedly magnetic after continued heating on charcoal. During fusion in the forceps the mineral imparts to the flame the pale bluish-green color characteristic of a phosphate. Fused in a sodium carbonate bead in the oxidizing flame, the green color characteristic of manganese is obtained. The mineral is readily soluble in hydrochloric acid, and if a little of the concentrated solution on a watch glass is brought in contact with a drop of dilute sulphuric acid a precipitate of calcium sulphate is formed. In the closed tube only a trace of water is given off, and at a full red heat the material shows signs of fusion.

The crystallization of graftonite is monoclinic, although no material for obtaining exact and reliable data has thus far been found. The crystals are without exception dark from the presence of oxidized triphylite, while the outer surfaces of the graftonite itself have undoubtedly suffered more or less oxidation. In some cases oxidation and decomposition have gone on to such an extent that only a rude suggestion of the crystal form remains. The crystals, moreover, are either fragmentary, or they are attached so that only a portion of their faces are developed. The crystals averaged over 4^{cm} in greatest diameter, and admitted only of approximate measurement by means of the contact goniometer.

The forms observed, which are represented in the accompanying figures, are as follows:

a, 100	*m*, 110	*n*, 130	*e*, 021
b, 010	*l*, 120	*d*, 011	*p*, 111

In establishing the axial ratio the value of β was derived from a direct measurement of the angle made by the edge between *b* and *e*, fig. 2, with the vertical edge between *b* and *n*. Other fundamental measurements were, $b \wedge m, = 51°$ and $b \wedge d = 62°$. The axial ratio obtained from these values is as follows:

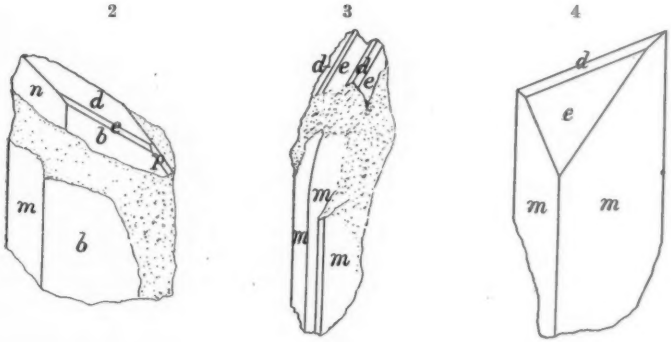
$$a : b : c = 0{\cdot}886 : 1 : 0{\cdot}582 ; \beta = 66°$$

It must be borne in mind, however, that the fundamental measurements are not very reliable, and that the axial ratio therefore can only be approximately correct.

A few of the more important measured and calculated angles are as follows:

	Measured.	Calculated.
$m \wedge m$, $110 \wedge 1\bar{1}0$ =	.....	78° 00′
$l \wedge l$, $120 \wedge 1\bar{2}0$ =	115°	116 36, fig. 6
$b \wedge n$, $0\bar{1}0 \wedge \bar{1}30$ =	22 30′	22 22, fig. 2
$e \wedge e$, $021 \wedge 0\bar{2}1$ =	.....	93 31
$p \wedge p$, $111 \wedge 1\bar{1}1$ =	.....	41 32

Figures 2 to 7 represent the crystals which were available for study. Fig. 2, drawn with b, $0\bar{1}0$, in front, shows a portion of a crystal, about 5^{cm} wide, which is attached to a rather large, irregular mass of graftonite associated with biotite. In this and in other figures no attempt has been made to represent by means of an artistic effect the irregular, broken surfaces of the graftonite and associated minerals. The stippled portions of the figures are intended to represent the irregular surfaces, and, if carried out in the proper proportion in fig. 2, the stippling



should continue for a considerable distance above and to the right, beyond the limits of the figure. Fig. 3 represents two crystals, about 7^{cm} long, which have grown together in parallel position and have suffered deformation, the vertical edges and faces of the prism being decidedly curved, although the monosymmetric character of the crystal seems not to have been disturbed. No cracks, resulting from cleavage or fracture, are visible in this specimen, and no other specimen was observed which showed similar deformation. Figs. 4, 5, 6 and 7 represent fragments and corners of much decomposed crystals with rough faces. The material as a whole was very unfavorable for crystallographic study, and it is possible that the conclusions reached concerning the orientation of some of the crystals and the identification of the forms are erroneous, although, as far as could be told with the contact goniometer, the measure-

ments indicated the simple forms which have been recorded in the foregoing list.

The optical properties of the graftonite, as far as they were studied, indicate monoclinic symmetry. The lamination, as will be explained more in detail later, is parallel to the pinacoid *b*, 010, of the graftonite, and hence a section like that represented by fig. 1, cut at right angles to the lamination, is at

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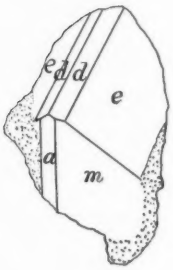

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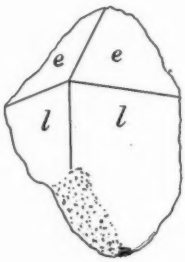

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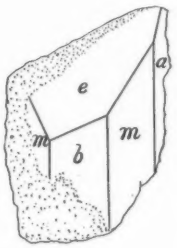

right angles to the symmetry plane. Two sections were thus prepared from the small fragment of fresh material, and, except that they were at right angles to the symmetry plane, nothing is known concerning their orientation. In these sections, when examined in polarized light, the graftonite was found to have an extinction parallel to the lamination, as indicated by the arrows, fig. 1. In one of the sections, when examined in convergent polarized light, a portion of a biaxial interference figure was observed toward the limit of the field, and the position of the figure indicated distinctly that the plane of the optical axes is at right angles to the symmetry plane, the acute bisectrix being in the symmetry plane. By mounting a small fragment of the thin section on the little axial angle apparatus devised by Professor Klein,* filling the vessel with a liquid of high index of refraction, and turning until the bisectrix came to the center of the field of the polariscope, the horizontal character of the dispersion could be distinctly seen, and it was estimated that the divergence of the optical axes, 2 V, was about 50° to 60°. The birefringence is not very strong and its character is positive.

The interlamination of two minerals such as graftonite and triphylite, differing in chemical composition and crystallizing in different systems, is an interesting and unusual phenomenon which seemed worthy of some study. Before discussing the

* Groth's Physikalische Krystallographie, 1895, fig. 690, p. 750.

problem presented by this particular intergrowth, however, it may be well to cite a few illustrations of a somewhat similar nature. The best and undoubtedly the most familiar illustration of the lamellar intergrowth of two minerals is that of albite (triclinic) and orthoclase (monoclinic), a phenomenon commonly observed in studying thin sections of rocks, and familiarly known to petrographers as the perthitic or microperthitic structure. In the case of the feldspars the two minerals are closely related both in chemical composition and crystalline form, they are united by their pinacoid faces *b*, 010, having their vertical axes parallel, and thus the cleavage directions and the interfacial angles of the two minerals conform very closely to one another. Other familiar instances of parallel, though not of lamellar intergrowth are of staurolite (orthorhombic) on cyanite (triclinic), rutile (tetragonal) on hematite (hexagonal-rhombohedral), and chalcopyrite (tetragonal) on both tetrahedrite and sphalerite (isometric). In each of these cases it is probable that the two minerals have certain molecular or crystallographic features so nearly alike that the two substances can grow together in certain definite positions, somewhat analogous to the growth of two crystals of the same material in parallel or in twin position.

Evidently the most important thing to be determined in connection with the study of the interlamination of the monoclinic graftonite and the orthorhombic triphylite is the manner in which the two minerals are intergrown. Undoubtedly the graftonite, which makes up from two-thirds to three-quarters of the total mass of the crystals, has exerted the controlling influence upon the crystalline form, for the external shape of the crystals is monoclinic and not orthorhombic. In all of the specimens the lamination is very pronounced and parallel to the clinopinacoid *b*, 010, of the graftonite; however, the surfaces by which the two minerals are united are not plane and even, like cleavage or crystal faces, but undulatory, somewhat resembling in miniature a surface presented by a slab of sedimentary rock exhibiting ripple marks. An idea of the uneven character of the surfaces may be gained by noting the irregular, wavy lines of juncture between the two minerals as seen in cross section, fig. 1. In the specimen represented by fig. 2 there was a limited area where the lamination was apparently parallel to the prism *m* of the graftonite, but in other parts of the specimen and in all other crystals the lamination was throughout parallel to the clinopinacoid *b*.

When a section like fig. 1 is examined in polarized light, the graftonite, as already stated, shows parallel extinction; the extinction of the triphylite, however, in the particular section under consideration, is inclined about 27° to the direction of

lamination, and differently in different lamellæ, as indicated by the arrows, fig. 1. In lamellæ 1, 3 and the upper part of 5 the extinction is to the right, while in 2, 6, 7 and the lower part of 5 it is to the left. Thus evidently the orthorhombic triphylite and the monoclinic graftonite have not intergrown with pinacoid faces in common, for in that case both minerals would have shown parallel extinction. The inclined extinction of the triphylite naturally suggested the idea that one of its prism or dome faces might be parallel to the clinopinacoid of the graftonite, and, on looking for some similarity between the forms and angles of the two minerals, it was observed that the angle of the macrodome 102 of triphylite ($102 \wedge \bar{1}02 = 62° 23'$) was practically the same as the angle between the clino-dome *d*, 011, and the clino-pinacoid *b*, 010, of graftonite ($011 \wedge 010 = 62°$). If therefore a triphylite crystal is orientated so that its macro-axis is parallel to the clino axis of graftonite, and is then tipped 31° so that a dome face 102 comes in contact with the clinopinacoid *b* of graftonite, then the clinodome *d* of the graftonite and the macrodome of the triphylite fall practically in one plane. In trying to find other points of similarity which the two minerals might possess, recourse was had to the spherical projection. Fig. 8 represents in its full lines the spherical projection of graftonite, the location of the forms recorded on p. 24 being indicated by italic letters, while the location of four forms, 001, 031, $\bar{3}01$ and $\bar{2}21$, which were not observed as crystal faces, are indicated by indices in small figures. The projection of the triphylite is given in dotted lines, the known forms being indicated by heavy, full-faced letters, while the indices of a few possible forms are also given in heavy figures. The lettered forms of the triphylite are as follows:

B, 010	M, 110	W, 102	V, 302
C, 001	L, 120	E, 101	D, 021

As a starting point in constructing the projection of the triphylite, the zone in which 100 and C, 001, are located was made to coincide with the zone *b*, *d*, *d*, of the graftonite, and the location of two faces of the macrodome W of the triphylite to coincide, one with the clinodome *d*, the other with the clinopinacoid *b* of the graftonite. Thus, as shown by the figure, the forms C, V and 100 of triphylite correspond closely to 031, 001 and *d*, $0\bar{1}1$ of graftonite respectively. A zone W, 122, M, W of triphylite is almost coincident with that joining *b* and *p* of graftonite, though the forms M and 122 of the former are located several degrees distant from the pyramid *p* of the latter. Finally the faces of the dome D, 021 and $0\bar{2}1$, of triphylite fall one within about 3° of the prism

m, the other about 5° of a possible pyramid $\bar{2}21$ of graftonite. It must furthermore be borne in mind that the variable elements, that is, the axial ratios, of both triphylite and graftonite have been derived from measurements made with only a contact goniometer, hence the correspondence between the two minerals may be even closer than is indicated by their position as plotted on the spherical projection.

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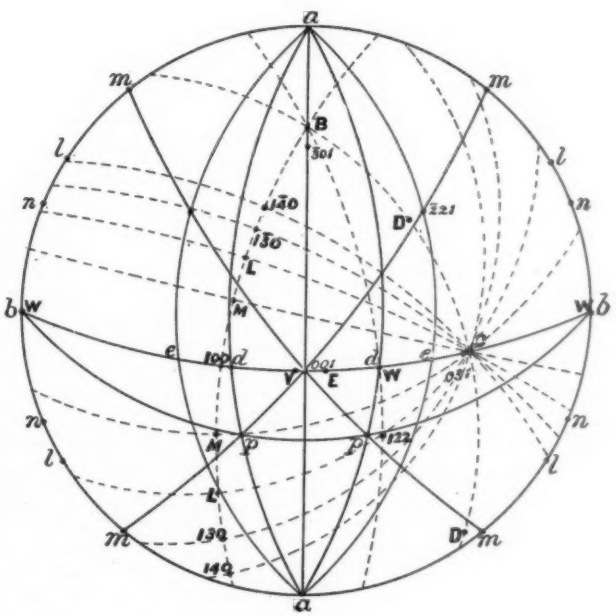

Another and perhaps a more convincing method of showing similarity between the two minerals is given by fig. 9. This represents at the left a monoclinic combination of the forms *m* and *d* of graftonite, with the right hand edge of the prism truncated by a clinopinacoid *b*. To the right is a triphylite crystal, representing a combination of the domes W, 102, and D, 021, accurately plotted, and drawn so that one of the W faces is in contact with the clinopinacoid of the graftonite and the edge W∧W parallel to the clino-axis of the latter mineral. Thus drawn, a *d* face of the one crystal and a W face of the other fall almost exactly in one plane (W∧W = 62° 23′ and *b*∧*d* = 62°), and, also a brachydome face D of the triphylite

is almost parallel to the prismatic face *m*, 110, of the graftonite, as shown by the fact that the edges between *m* and *d* and W and D, fig. 9, form almost a continuous line, or from fig. 8, that the angle between *d* and *m* ($011 \wedge 110 = 54° 56'$) is almost the same as that between W and D ($102 \wedge 021 = 53° 54'$)

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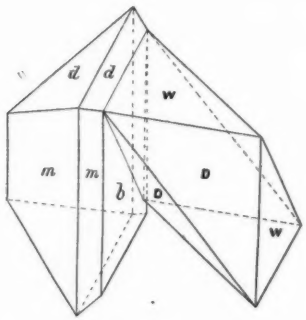

The foregoing demonstrations furnish a working hypothesis for explaining how the two minerals might possibly have grown together because of similarity in certain prominent crystallographic features, and it remains to be shown to what extent the hypothesis conforms to the structural features presented by the intergrowth of the two minerals. In fig. 10 there is represented in the center an ideal cross-section of a graftonite crystal, at right angles to the clino-axis, and showing the outlines of the forms *d* and *b*. Such a section should exhibit in polarized light parallel extinction, as is the case with the graftonite in fig. 1. On either side of the graftonite in fig. 10 are represented sections of triphylite crystals at right angles to the macro-axis *b* and so orientated that faces of the macrodome W are parallel to and in contact with the clinopinacoid *b* of the graftonite; compare fig. 9. Such sections should show extinction angles of 31° to the right and to the left of the interposed graftonite, as indicated by the arrows. The structure indicated by the ideal section, fig. 10, corresponds to the optical properties of the minerals in the section represented by fig. 1, where the interlaminated triphylite (compare lamellæ 1, 2 and 3) shows inclined extinction, symmetrically disposed to the right and to the left of the plane of lamination. If a cross section of the composite crystal were at right angles to the symmetry plane of the graftonite, but not at right angles to the clino-axis, then the extinction angles of the triphylite would be less than 31°, but still remain equal on either side of

the plane of lamination. In the section represented by fig. 1 the extinction angle of the triphylite is about 27°; hence, if the hypothesis which is proposed is the correct one, the section should be nearly though not quite at right angles to the clino-axis of the graftonite and the macro-axis of the triphylite. Furthermore, according to the investigation of Penfield and

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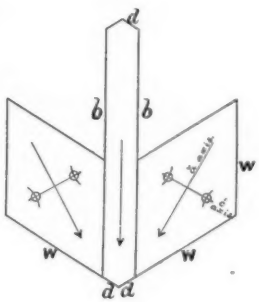

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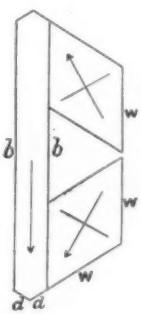


Pratt,* it may be assumed that in triphylite having about 33 per cent. of FeO the acute bisectrix is the *b*-axis, the plane of the optical axes being 100, as indicated by fig. 10, and the divergence of the optical axes, 2 V, about 80°. Hence in a section similar to fig. 10, at right angles to the *b*-axis of the triphylite, the latter should show a bisectrix; while if slightly inclined, as may be assumed to be the case in the section represented by fig. 1, some portion of the interference figure ought to be visible. This in reality is the case when the tryphylite lamellæ are examined, although, owing to the character of the material, the interference figures are not very distinct. Thus the optical properties, as far as they have been made out, confirm the hypothesis that a dome face of the triphylite is in contact with a clinopinacoid face of the graftonite. Fig. 11 represents two crystals of triphylite orientated in twin position to one another upon a clinopinacoid face of graftonite. Crystals thus orientated, provided they increased in size, would have to adapt themselves to circumstances as they grew together, and the surface of contact between them would probably be irregular and not conformable to any definite crystal plane. Such a condition may have existed when lamella 5, fig. 1, was forming, for in one portion the extinction is to the right, in another to the left, while the two portions unite along an

* This Journal, III, l, p. 387, 1895.

irregular line which can be distinctly traced under the microscope.

The composite crystals of graftonite and interlaminated triphylite are large, and, therefore, it seems probable that a very long time would be required for their growth and development. It does not seem probable that the crystals could have been originally of one material and subsequently, without oxidation of the iron or manganese, have been changed in part to a material of different composition. The acceptance of such a theory would require that the product resulting from the alteration (in this case the rare mineral triphylite) should have developed as interspersed lamellæ having definite crystallographic orientation with reference to the original material. Again it does not seem probable that they were at one time wholly graftonite, and that later, by pressure or other agency, they were broken up into lamellæ, leaving interstices for the subsequent infiltration of triphylite as a cementing material. The crystals, with the exception perhaps of the one represented by fig. 3, show no evidence of having been crushed and cemented together, nor are there any inequalities, striations or offsets visible on their faces to lead one to suspect that the crystals have been opened out and broadened as a result of the interlaminated triphylite. It seems rather probable that the crystals must have developed in a solution or medium which contained the chemical constituents for the formation of both compounds, and that the growth was of such a nature that graftonite was deposited at one period and triphylite at another. Thus, according as the supply of material favorable for the formation of the one compound or the other was most abundantly at hand, the growth of the crystals proceeded until the large interlaminated individuals were formed.

It is to be regretted that only one small fragment of fresh unaltered material, without definite crystal faces, was found. The material as a whole was of such a nature that accurate crystallographic measurements could not be made, and orientated sections containing unaltered triphylite could not be prepared, hence the crystallographic relations of the two minerals have not been established with absolute certainty. It is hoped, however, that the time devoted to finding even a possible explanation of the remarkable intergrowth presented by the two minerals has not been spent in vain.

Laboratory of Mineralogy and Petrography,
Sheffield Scientific School of Yale University, November, 1899.

Art. V.—*Explorations of the "Albatross" in the Pacific Ocean;* by Alexander Agassiz.

[Extract from a letter to the Hon. George M. Bowers, U. S. Commissioner of Fish and Fisheries. Washington, D. C., dated Papeete Harbor, Tahiti Island, 30 September, 1899, on the trip of the "Albatross" from San Francisco to Papeete.]

I arrived at San Francisco on August 20th, and after consulting with Commander Moser we decided to leave on Wednesday, the 23d. Everything shipped from the East had arrived with the exception of the tow nets sent me by Dr. Kramer, and the deep-sea nets kindly ordered for me by Professor Chun of Leipzig. Captain Moser and I decided not to make any soundings nor do any deep-sea work until we had passed beyond the lines of soundings already run by the Albatross and Thetis between California and the Hawaiian Islands.

In latitude 31° 10′ N., and longitude 125° W., we made our first sounding in 1955 fathoms, about 320 miles from Point Conception, the nearest land. We occupied 26 stations until we reached the northern edge of the plateau from which rise the Marquesas Islands, having run from station No. 1, a distance of 3800 miles, in a straight line.

At station No. 2 the depth had increased to 2368 fathoms, the nearest land, Guadeloupe Island, being about 450 miles, and Point Conception nearly 500 miles, distant. The depth gradually increased to 2628, 2740, 2810, 2881, 3003, and 3088 fathoms, the last in lat. 16° 38′ N., long. 130° 14′ W., the deepest sounding we obtained thus far in the unexplored part of the Pacific through which we were passing. From that point the depths varied from 2883 to 2690 and 2776, diminishing to 2583, and gradually passing to 2440, 2463, and 2475 fathoms until off the Marquesas, in lat. 7° 58′ S., long. 139° 08′ W., the depth became 2287 fathoms. It then passed to 1929, 1802, and 1040 fathoms in lat. 8° 41′ S., long. 139° 46′ W., Nukuhiva Island being about 20 miles distant. Between Nukuhiva and Houa-Houna (Ua-Huka) Islands we obtained 830 fathoms, and 5 miles south of Nukuhiva 687 fathoms. When leaving Nukuhiva for the Paumotus we sounded in 1284 fathoms about 9 miles south of that island. These soundings seem to show that this part of the Marquesas rises from a plateau having a depth of 2000 fathoms and about 50 miles in width, as at station 29 we sounded in 1932 fathoms.

Between the Marquesas and the northwestern extremity of the Paumotus we occupied nine stations, the greatest depth on

that line being at station No. 31, in lat. 12° 20′ S., and long. 144° 15′ W. The depths varied between 2451 and 2527 fathoms and diminished to 1208 fathoms off the west end of Ahii, and then to 706 fathoms when about 16 miles N.E. of Avatoru Pass in Rairoa Island.

We developed to a certain extent the width of the Paumotu Group plateau by a line of soundings in continuation of the direction of Avatoru Pass, extending a little less than 9 miles seaward, where we obtained a depth of 819 fathoms. Subsequently we ran a similar line normal to the south shore of the lagoon of Rairoa, a distance of nearly 12 miles, into 897 fathoms.

Between Rairoa and Tikehau, the next island to the westward, we got a depth of 1486 fathoms.

Between Tikehau and Mataiwa six soundings were made with a depth of 488 fathoms half a mile from shore, and a greatest depth of 850 fathoms 6½ miles from Tikehau. The slope approaching Mataiwa is steeper than the Tikehau slope.

From Mataiwa to Makatea (Aurora) Island, we made six soundings: from 642 fathoms about 2½ miles off shore, to 581 fathoms about 1⅛ miles off the west side of the latter island, the depths passing to 860, 1257, 1762, and the greatest depth being 2267 fathoms; then 2243, and rising more rapidly near Makatea to 581 fathoms.

Between Makatea and Tahiti we made eight soundings, beginning with 1363 fathoms, 2 miles off the southern end of Makatea, passing to 2238, 2363 (the greatest depth on that line), to 2224, 1930, 1585, 775, and finally 867 fathoms off Point Venus.

These make in all 72 soundings up to the present time.

The deep basin developed by our soundings between lat. 24° 30′ N., and lat. 6° 25′ S., varying in depth from nearly 3100 fathoms to a little less than 2500 fathoms, is probably the western extension of a deep basin indicated by two soundings on the charts, to the eastward of our line, in longitudes 125° and 120° W., and latitudes 9° and 11° N., one of over 3100 fathoms, the other of more than 2550 fathoms, showing this part of the Pacific to be of considerable depth and to form a uniformly deep basin of great extent, continuing westward probably, judging from the soundings, for a long distance.

I would propose, in accordance with the practice adopted for naming such well-defined basins of the ocean, that this large depression of the Central Pacific, extending for nearly thirty degrees of latitude, be named Moser Basin.

The character of the bottom of this basin is most interesting. The haul of the trawl made at station No. 2, lat. 28° 23′ N., long. 126° 57′ W., brought up the bag full of red clay and manganese nodules with sharks' teeth and cetacean ear-bones;

and at nearly all our stations we had indications of manganese nodules. At station No. 13, in 2690 fathoms, lat. 9° 57′ N., long. 137° 47′ W., we again obtained a fine trawl haul of manganese nodules and red clay; there must have been at least enough to fill a 40-gallon barrel.

The nodules of our first haul were either slabs from 6 to 18 inches in length and 4 to 6 inches in thickness, or small nodules ranging in size from that of a walnut to a lentil or less; while those brought up at station No. 13 consisted mainly of nodules looking like mammillated cannon-balls varying from 4½ to 6 inches in diameter, the largest being 6½ inches. We again brought up manganese nodules at the equator in about longitude 138° W., and subsequently—until within sight of Tahiti—we occasionally got manganese nodules.

As had been noticed by Sir John Murray in the Challenger, these manganese nodules occur in a part of the Pacific most distant from continental areas. Our experience has been similar to that of the Challenger, only I am inclined to think that these nodules range over a far greater area of the Central Pacific than had been supposed, and that this peculiar manganese-nodule bottom characterizes a great portion of the deep parts of the Central Pacific where it cannot be affected by the deposits of globigerina, pteropods, or telluric ooze; in the region characterized also by red-clay deposits. For in the track of the great equatorial currents there occur deposits of globigerina ooze in over 2400 fathoms for a distance of over 300 miles in latitude.

Manganese nodules we found south of the Marquesas also, when in 2700 fathoms we obtained perhaps the finest specimens of red clay from any of our soundings. As we approached close to the Western Paumotus, upon the north side of the plateau from which they rise, globigerina ooze passed gradually to pteropod ooze, then to fine and coarse coral sand. In the channel south of the Paumotus to Tahiti the coral sand passed to volcanic sand mixed with globigerinæ in the deepest parts of the line, and toward Tahiti passed to volcanic mud mixed with globigerinæ, next to fine volcanic sand, and finally, at the last sounding, off Point Venus, to coarse volcanic sand.

We made a few hauls of the trawl on our way, but owing to the great distance we had to steam between San Francisco and the Marquesas (3800 miles) we could not, of course, spend a great deal of time either in trawling or in making tows at intermediate depths. Still the hauls we made with the trawl were most interesting, and confirmed what other deep-sea expeditions have realized: that at great depths, at considerable distances from land and away from any great oceanic current, there is comparatively little animal life to be found. Where

manganese nodules were found the hauls were specially poor, a few deep-sea holothurians and ophiurans, and some small actiniæ which had attached themselves to the nodules with a few other invertebrates, seemed to be all that lived at these great depths, 2500 to 2900 fathoms, far away—say from 700 to 1000 miles—from the nearest land.

The bottom temperatures of the deep (Moser) basin varied between 34·6° at 2628 and 2740 fathoms, to 35·2° at 2440 fathoms, and 35° at 2475 fathoms; about 120 miles from the Marquesas. At station No. 23, off the Marquesas, in 1802 fathoms, the temperature was 35·5°.

Owing to the failure of our deep-sea thermometers we were not able to make any satisfactory serial-temperature observations. At station No. 11, lat. 14° 38′ N., long. 136° 44′ W., we obtained:

79°	at surface	
78·7°	at 50	fathoms
55·9°	" 100	"
48·9°	" 200	"
44·1°	" 300	"
39·9°	" 700	"

These temperatures are somewhat higher than those obtained by the Challenger in similar latitudes on their line to the westward of ours between the Sandwich Islands and Tahiti.

The temperatures of the bottom between the Marquesas and Paumotus were 34·9° at 1932 fathoms, 35° at 2456 fathoms and 2451 fathoms, and 35·1° at 2527 fathoms.

We did not take any bottom temperatures between the Paumotus and Tahiti.

Our deep-sea nets not having reached San Francisco at the time we sailed, we limited our pelagic work to surface hauls, of which we generally made one in the morning and one in the evening, and whenever practicable some hauls with the open tow nets at depths varying between 100 and 350 fathoms. The results of these hauls were very satisfactory. The collection of surface animals is quite extensive, and many interesting forms were obtained. As regards the deeper hauls, they only confirm what has been my experience on former expeditions, that beyond 300 to 350 fathoms very little animal life is found, and in the belt above 300 fathoms, the greater number of many so-called deep-sea crustaceans and deep-sea fishes were obtained. I may mention that we obtained Pelagothuria at about 100 fathoms from the surface.

We trawled at station No. 10 in 3088 fathoms. Unfortunately the trawl was not successful, and we simply hauled the bag through over 3000 fathoms without bringing up a single deep-sea animal from intermediate depths which we did not

obtain quite near the surface—at less than 300 fathoms. I may mention here that the experience of the Valdivia shows, from the preliminary reports published by Professor Chun, that no pelagic algæ extend to beyond about 150 fathoms. Although he also states that animal life is found at all depths from the surface to the bottom, yet he states that beyond 800 meters it diminishes *very rapidly;* Professor Chun does not state whether this diminution is more rapid away from land than near continental areas, both of which conditions I had called especial attention to in my Preliminary Report on the Albatross expedition of 1891, while using the Tanner net in the Gulf of California. Mr. George Murray has criticized the action of the Tanner deep-sea net, and condemns its results, suggesting that the bottom net had always closed some time after being sent down. I need not now discuss that subject, but will only refer him to the report of the Albatross, in which he will find the closed part of the net to have on several occasions brought up (when I expected it to do so) specimens from over 600 fathoms from immediately above the bottom, or samples of the bottom from near 1700 fathoms while attempting to tow immediately above that depth. I ought, in justice to him, to state that I omitted to mention that we secured the loops by twine to the detacher to insure their dropping only when the messenger reached the detacher, and that the hooks of the detacher were lengthened very considerably above the dimensions figured in my Preliminary Report on the Albatross expedition of 1891. I might add that we made a number of trials near the surface to see the action of the Tanner net under all conditions of position and speed, and I can only assume that Mr. Murray, having no experience, did not handle his net properly, or that it was not properly balanced. I may also add that Captain Tanner used his modified net subsequently in the Albatross, while running a line of soundings from San Francisco to the Hawaiian Islands, in from 100 to 350 fathoms from the surface, at considerable distances from the islands and the mainland, and also in Alaskan waters, and always with the results we had obtained before. The closed bag, when towing at 100 fathoms below the surface, always brought up a mass of pelagic animals living at about that depth, while when tried at 300–350 fathoms it brought up little or nothing. There is nothing in Captain Tanner's experience, or mine, to indicate why the net should act well at 100 fathoms and not well at 300 fathoms or more, as suggested by Mr. Murray.

On our way to Tahiti from the Marquesas we stopped a few days to examine the westernmost atolls of the Paumotus. Striking Ahii we made for Rairoa, the largest atoll of the

Paumotu group. Skirting the northern shore from a point a little west of Tiputa Pass, we entered the lagoon through Avatoru Pass, anchoring off the village. This pass is quite narrow, with a strong current running out the greater part of the time, especially in easterly winds. It varies in depth between 9 and 10 fathoms, shoaling near the inner entrance to about 3½ fathoms, and deepening again to 6 or 7 fathoms, and gradually passing into 15 to 17 fathoms, which is the average depth of the lagoon from Avatoru Pass to the south or weather shore, a distance of about 13 miles.

We made an examination of the northern side of the lagoon between Avatoru and Tiputa Passes. The lagoon beach of the northern shore is quite steep, and is composed of moderately coarse broken coral sand at the base, and of larger fragments of corals along the upper face, which is about 5 to 6 feet above high-water mark. These coral fragments are derived in part from the corals living on the lagoon face of the northern shore, and in part of fragments broken by the waves from somewhat below the low-water mark. The ledge which underlies the beach crops out at many places on the lagoon side of the northern shore; we traced it also along the shores of Avatoru Pass, and about half way across the narrow land running between Avatoru and Tiputa Passes. It crops out also at various points between them in the narrow cuts which divide this part of the northern land of the lagoon into a number of smaller islands. These secondary passes leave exposed the underlying ledge, full of fossil corals. In some cases there is left a clear channel extending across from the lagoon to the northern side through which water flows at high or half tide. In other cases the cuts are silted up with coral sand blown in from the lagoon side. In others, the cut is shut off by a high sand-bank, or a bank composed of broken fragments of corals, leaving access to the water from the northern shore only; and finally the cuts are also shut off on the northern side by sand and broken coral banks, the extension of the north-shore beach leaving a depression which at first is filled with salt-water and gradually silted up both from the lagoon side and the sea side, and forms the typical north-shore land of the lagoon. This building up of the land of the Paumotu atolls simultaneously both by the accumulation of sand from the lagoon side and the sea face, is very characteristic of the atolls of that group. It is a feature which I have not seen so marked in any other coral reef district.

On the lagoon side the slope from the beach is very gradual into 16 and 17 fathoms, and corals appear to flourish on the lagoon slope to 6 or 8 fathoms only, in some cases consisting of Madrepores, Porites, Astræans and Pocillopores. The corals

could be seen over the floor of the Avatoru passage down to from 9 to 10 fathoms; and on the sea face Pocillopores covered the outer edge of the shore platform. This platform is from 200 to 250 feet wide, and was formed by the planing off of the seaward extension of the ledge cropping out in the cuts.

It became very evident, after we had examined the south shore of the lagoon, that the ledge underlying the north shore is the remnant of the bed, an old Tertiary coralliferous limestone which at one time covered the greater part of the area of the lagoon, portions of which may have been elevated to a considerable height. This limestone was gradually denuded and eroded to the level of the sea. Passages were formed on its outside edge, allowing the sea access to the inner parts of the lagoon. This began to cut away the inner portions of the elevated limestone, forming large sounds, as in the case of Fiji atolls, and leaving finally on the south side only a flat strip of perhaps 2,500 to 3,000 feet width which has gradually been further eroded on the lagoon side, and also on the sea face to leave only a narrow strip of land about 1,000 feet in width and perhaps 10 to 14 feet in height, the material for this land having come from the disintegration of the ledge of Tertiary limestone, both on the sea face and the lagoon side.

There exist in the lagoon a number of small islets which also consist of this same Tertiary limestone in process of disintegration and transformation to coral sand islets. They are the islets at the lagoon side of both Avatoru and Tiputa Passes, the two islets which we found along our line of soundings, the one about 4½ miles from the north side of the lagoon, and the other about the same distance from the south shore. I am told that the eastern extremity of the lagoon is filled with islets and heads consisting of the same limestone rock so characteristic of the north and south shores of the lagoon.

The underlying ledge is not the remnant of a modern reef; its character is identical with that of the elevated limestones of Fiji, which are of Tertiary age, and the rock is in every respect the same as that I observed on many of the elevated islands of Fiji. The atoll of Rairoa is in a stage of denudation and erosion very similar to that of Ngele Levu, in Fiji, only in Ngele Levu the elevated limestone attains a height of about 60 feet. Our visit to the south shore of the lagoon, both on the lagoon side and on the sea face, left us no doubt regarding the character of the underlying ledge of the north shore. As soon as the south shore was sufficiently near, as seen from the lagoon side, for us to distinguish its character, we could see that the entire shore line was formed of a high ledge of lime-

stone, honeycombed, pitted and eroded, both by atmospheric agencies, and the action of the waves, in its lower parts both on the lagoon side and on the sea face. The great rollers of the weather side broke through between the columnar masses of the ledge into the lagoon, and as far as the eye could reach there extended a more or less continuous wall (which is described by Dana as he saw it sailing by in the Vincennes). But in addition to this we found, on landing, this wall to be the sea face of the islands and islets which dot the weather side for the greater part of its length on the southwestern part of the lagoon.

These islands and islets are entirely composed of coral sand and coral fragments, formed from the disintegration of the extension of the elevated ledge toward the inside of the lagoon to a distance of about 1½ to 2 miles; and along this very gradual slope of the islands forming the southern edge of Rairoa, corals grow profusely down to 6 or 7 fathoms of water, when the bottom runs into hard coralline bottom similar to that found on all the soundings taken across the lagoon.

The width of the larger islands is about 1000 to 1200 feet; the smaller islands and islets are less, some of the latter forming in reality mere sand buttresses at right angles to the great limestone ledge which flanks them all on the sea face and connects them on the weather side as if by a great wall, more or less broken, and shuts off the communication of the interior of the lagoon with the sea on that side.

The passages between the islands and islets illustrate well, only on a larger scale, the formation of the cuts, more or less silted up, which were observed on the northern face of the lagoon. Some of these passages are dry at low-water, others are partly filled by tide pools, others are entirely silted up by lagoon sand, only they are lower than the sand-blown land of the islands on either side of it.

Crossing over to the weather side of the southern land of Rairoa in one of the passages between two of the islands, we came upon the limestone ledge, from 12 to 14 feet high and about 40 to 50 feet wide, which formed the sea face of the islands and islets, and extended far to the westward as a great stone wall more or less broken into distinct parts. We found this ledge to consist of elevated limestone as hard as calcite, full of corals, honeycombed and pitted, and worn into countless spires and spurs, and needles and blocks of all sizes and shapes, separated by deep crevasses or potholes recalling a similar scene in Ngele Levu on the windward end of the lagoon. In the passages the parts of the ledge which had not been eroded, extended as wide buttresses, gradually diminishing in height till they formed a part of the lagoon flat and extended out below the recent beach rock which covered it in short stretches.

The slope of the sea face of the elevated ledge was quite steep and similar to the lagoon slope, and its upper surface weathered by atmospheric and aqueous agencies into all possible shapes such as I have mentioned. The slope passed into the shore platform, which was shaved down as it were to a general level surface. On the outer edge, within the line of the breakers, were growing Pocillopores in great abundance. This reef flat or shore platform, as well as the reef platform of the north shore, was strewn here and there with huge masses of the ledge of elevated reef rock torn from its outer shore. Similar rocks and bowlders occur on the lagoon side of the islands forming the outer lands of Rairoa; they are either torn off from the lagoon face of the outcropping ledge, or are parts of the ledge which have remained in place and have not been planed down to the base level of the reef.

The amount of water which is forced into such a lagoon as Rairoa is something colossal, and when we observe that there are but a small number of passages through which it can find its way out again on the leeward side, it is not surprising that we should meet with such powerful currents (7 to 8 knots in several cases) sweeping out of the passages on the lee sides.

The islands and islets of Rairoa are fairly well covered with low trees and shrubs and large groves of palm trees.

The atolls of Tikehau and Mataiwa, which we also examined, present no features which we did not meet in Rairoa. The first-named atoll shows the same method of formation of the land by material piled up both from the lagoon side and the sea face; material derived from the disintegration of the underlying Tertiary limestone which crops out here and there along the sea face and the inner shores of the lagoon, or forms across the S.W. face of the lagoon an irregular disconnected part of the ring of islands and islets encircling that end of the lagoon. These islets and islands are more or less connected by fragments of the elevated limestone ledge, attesting its greater extension in past times. The outer rings of both these atolls are covered with vegetation. We could see in the lagoons several rocky islets, the fragments of the elevated limestone ledge.

Mataiwa is interesting, as its lagoon is quite shallow; it is full of rocky islets, remnants of the underlying limestone ledge which crops out above the general level, and has a very narrow and shallow entrance, passable for boats only. Some of its islands are wooded and appear to have been formed by accretion of sand from the decomposing ledges of the lagoon. The outer ring of land appears formed by sand banks driven in from the sea face and driven out from the lagoon side by the action of the waves. It is evident that such a lagoon as

Mataiwa could readily be closed to any access to it by the sea, as it now has only one very narrow and very shallow boat passage connecting the lagoon with the sea on the lee side.

It was with great interest that we approached Makatea, as it is the only high elevated island of which Dana speaks as occurring in the western Paumotus. For though he mentions some others as possibly having been elevated 5 to 6 feet, yet he considered them all, as well as Makatea (Metia or Aurora, of Dana) as modern elevated reefs. Yet from the very description given by him of the character of the cliffs and of the surface of Makatea, I felt satisfied that it was composed of the same elevated coralliferous limestone so characteristic of the elevated reefs of Fiji, and which from the evidence of the fossils and the character of the rock, both Mr. Dall and myself have been led to regard as of Tertiary age.

As we approached the island from the northwest it soon became evident that it presented all the characteristics to which I had become so accustomed in Fiji, and, upon landing, this was found to be the case. The cliffs had the same appearance as those of Vatu Leile, Ongea, Mango, Kambara, and many other elevated islands of Fiji. There were fewer fossils perhaps, but otherwise the petrographic character of the rock was identical with that of Fiji. Mr. Meyer collected upon the top of the second terrace a number of fossils similar in all respects to those we found in the Fiji elevated coralliferous limestones.

The southwestern extremity of the island sloped gradually to the sea and showed two well-defined terraces. The lines of these two terraces could, as a rule, be traced along the faces of the vertical cliffs by the presence of caverns along the lines of those levels, similar to the lines of caverns indicating the line of present action of the sea at the base of the cliffs. As we steamed around the island there were distinct indications of two additional terraces on the line of the vertical cliffs on the weather side of the island. The position of these terraces was usually more clearly seen along the face of the cliffs at prominent points where they were undercut much as I have figured them for certain cliffs in Vatu Leile, in Fiji, in my report on the islands and coral reefs of that group.

Of course it is premature, from this examination of the western extremity of the Paumotus, to base any general conclusions regarding the mode of formation of those atolls; certainly as far as I have gone there is absolutely nothing to show that the atolls of the Paumotus have not been formed in an area of elevation similar to that of Fiji. The evidence in Rairoa and in the atolls of the western Paumotus is very definite. Makatea is an elevated mass of coralliferous limestone similar in all respects to masses like Vatu Vara, Thithia, and

others in Fiji. Like them, Makatea is surrounded by a comparatively narrow shore platform cut out from the base of the limestone cliffs and on the seaward extension of which corals grow abundantly to depths of 7 to 8 fathoms, when they appear to become very much less numerous. So that it is not unnatural to look upon the area of the Paumotus, as I am inclined to do, as one of elevation, the raised and elevated land of which has been affected much in the same way by denudation and by erosion, as have the masses of elevated coralliferous limestone of Fiji. Only, there seems to have been, from the evidence thus far presented a far greater uniformity in the height of the elevation of the Paumotus. This would render the explanation I have given less evident had I not the experience of the Fiji group to guide me. I am informed that there are other islands and atolls in the Paumotu group showing traces of this elevation, so that I am at any rate justified in denying that the Paumotus as such are situated in an area of subsidence, and that subsidence has been the great factor, as is maintained by Darwin and Dana, in the formation of the characteristic atolls of the group.

It may be well to point out also that the Paumotus, like the Marquesas on one side and the Society Islands on the other, are situated upon a plateau similar to that upon which the last mentioned groups are placed, a plateau rising from a general oceanic basin which surrounds them and which has a depth of from 2300 to 2500 fathoms, the plateau itself having a depth of 1200 to 1500 fathoms. Furthermore, evidence of this elevation is found at the two extremities of the Paumotu Plateau, at Makatea, an elevated island consisting of Tertiary coralliferous limestone, and at Gambier Islands, which are volcanic islands of considerable height.

ART. VI.—*Some Analyses of Italian Volcanic Rocks*, II; by HENRY S. WASHINGTON.

[Continued from p. 294, vol. viii.]

Ciminite, Monte Cimino, Viterbo.—In 1896* I described certain trachytic rocks from this region, giving them the name of ciminite, derived from this locality, where they are found in typical development. They are composed essentially of alkali and lime-soda feldspars, augite and olivine, the presence of the last mineral and their more basic character distinguishing them from the closely related vulsinites. Both from a chemical and mineralogical point of view they stand intermediate between the trachytes and the andesites and basalts, and are hence monzonitic in character. They belong to the group which Rosenbusch has called andesitic trachytes and trachydolerites† and for which Ransome‡ has proposed the name of latite.

As another analysis seemed desirable to establish the type more definitely, one was made of a specimen from a flow at La Colonetta, on the south slope of Monte Cimino. It is rather dark gray, dense and compact, with some vesicles. A few phenocrysts of glassy feldspar (orthoclase and labradorite), augite and olivine are visible. In thin section it resembles those already described, though olivine phenocrysts are somewhat more abundant, and the groundmass is denser, with a felt of minute orthoclase and some labradorite laths lying in a glassy base.

	I	II	III
SiO_2	57·31	55·44	55·46
TiO_2	0·40	0·16	0·16
Al_2O_3	14·71	18·60	15·36
Fe_2O_3	1·21	2·09	1·34
FeO	4·37	4·48	4·50
MnO	trace	trace	trace
MgO	7·80	4·75	7·90
CaO	6·90	6·76	6·69
BaO	none	....	....
Na_2O	1·35	1·79	1·79
K_2O	6·38	6·63	6·63
H_2O (110°−)	0·18	0·25	0·15
H_2O (110°+)			0·23
P_2O_5	....	trace	trace
	100·61	100·95	100·21

* Jour. Geol., iv, p. 834, 1896; also v, p. 351, 1897.
† Rosenbusch, Elemente der Gesteinslehre, p. 339, 1898.
‡ Ransome, this Journal, vol. v, 355 and 364 ff, 1898.

I. Ciminite. La Colonetta, Monte Cimino.
II. Ciminite. Fontana Fiescoli,* Monte Cimino. Jour. Geol., iv, p. 837, 1896.
III. Ciminite. Fontana Fiescoli, Monte Cimino. New analysis.

The analysis (I) shows very clearly the intermediate character of these rocks in its medium SiO_2, rather low Al_2O_3, and high MgO, CaO and K_2O, which, taken together, are neither characteristic of an andesite or basalt on the one hand nor of a trachyte on the other. Since the rock is not holocrystalline a determination of the relative mineralogical composition is not perfectly sure, but a calculation based on the analysis indicates that, if the crystallization had been complete, the composition would have been as follows:

Orthoclase	37·9
Labradorite (Ab_4An_3)	26·5
Diopside	16·5
Olivine	17·3
Magnetite	1 8
	100·0

For comparison the original type analysis is reproduced in II. It will be seen that the two resemble each other in all particulars, except in Al_2O_3 and MgO, which are respectively lower and higher in the latest analysis. Suspicion was naturally aroused that in the older analysis, which, it may be mentioned, was the first complete rock analysis made by me, part of the MgO had been thrown down with the Al_2O_3 and Fe_2O_3. This is a mistake which is frequently made by chemists inexperienced in rock analysis, and one to which attention has been called by Pirsson,† Hillebrand‡ and myself.§

This supposition has been confirmed by a partial analysis, recently made, with an especially careful redetermination of MgO, several precipitations with NH_4HO in presence of sufficient NH_4Cl being made. In basic rocks a sodium acetate precipitation is always advisable. The results of this, combined with the reliable determinations of the first analysis, are given in III. This new analysis, it will be seen, corresponds very closely with that of the rock from La Colonetta, so that the chemical character of the type is well fixed.

It is with mixed feelings that I thus repudiate a former analysis, but the experience is of service to myself, as well as

* In former papers this name was erroneously given as "Fiesole," following an incorrect Austrian map. The spelling "Fiescoli" is that used on the Italian government maps.

† Pirsson, Jour. Geol., iv, p. 688, 1896.

‡ Hillebrand, Bull. 148, U. S. G. S., p. 39, 1897.

§ Washington, Jour. Geol., vii, p. 463, 1899.

to others, it is to be hoped, in emphasizing the necessity for extreme care in the determination of MgO, the neglect of which has rendered unreliable, as regards Al_2O_3 and MgO, many an otherwise good analysis.

"*Mica-trachyte*" (*Selagite*), *Monte Catini, Tuscany.*—The occurrence of this interesting rock forms part of a small hill, southwest of Volterra, with an area of about half a square kilometer. A rough columnar structure is quite evident. According to Reyer* the rock forms a surface flow, while according to Lotti,† with whose conclusions my own observations agree in the main, it forms a sort of stock or volcanic neck, which has come up through Tertiary marls. The age of the intrusion is undoubtedly Post-Eocene, and very probably Post-Pliocene, since marls apparently of this age have been altered at the contact.‡ Copper ores (erubescite, chalcopyrite, chalcocite, etc.) are mined in the vicinity, they occurring in connection with dikes of diabase or gabbro. The most abundant salt springs of Italy, from which the government obtains the greater portion of the salt used in the kingdom, are in the Val di Cecina near by.

The rock has long been known, having been described by Haüy,§ who named it "selagite," by which name it has been called by Italian geologists. Briefly noticed by various writers, it was first accurately described by Rosenbusch‖ in 1880, to whose description but little can be added.

The rock specimens show very many brown biotite flakes scattered through a dull, somewhat earthy, fine-grained, greenish-gray groundmass, giving it much the appearance of a minette. Under the microscope, sections show phenocrysts of biotite in large thin plates. These are of a rather pale pinkish or yellowish brown color, and are not very pleochroic. Many of them are quite colorless at the center, and occasionally one sees what seems to be a skeleton development, at the borders, producing, in basal sections, a fringe of small irregular hexagonal forms about the edges of the solid, and generally lighter colored, interior.

The groundmass is composed of small colorless crystals and anhedra of diopside, some green, fibrous, pilitic pseudomorphs after olivine, none of the original mineral being detected, and long narrow laths of feldspar, which is unstriated, and generally extinguishes parallel to the long axis, but which the investigations of Rosenbusch showed to be of both alkali-

* Reyer, Aus Toskana, Wien, 1884, p. 55.

† Lotti, Boll. R. Com. Geol. Ital, 1884, p. 36, and fig. 1, pl. viii.

‡ Lotti, Boll. R. Com. Geol. Ital., 1885, p. 254.

§ Cf. Zirkel, Lehrbuch, ii, p. 386, 1894, and Loewinson-Lessing, Petr. Lex., p. 213, 1894.

‖ Rosenbusch, Neues Jahrb, 1880, ii, p. 206.

feldspar and oligoclase. The amount of lime found on analysis indicates that the latter is present in considerable quantity. The feldspars are frequently branched and tend to assume keraunoidal forms. This is especially well seen in specimens near the contact with the marls, in which, although much decomposed, the branching of the feldspars (here more slender) is well developed. A few stout irregular grains of quartz (apparently secondary) and small apatites and magnetites are present, but are not common. Scarcely any true glass could be made out with certainty.

Even the freshest specimens from newly quarried large blocks are somewhat decomposed, since the olivines are all entirely altered to pilite, but the diopside, the feldspars, and apparently the biotite, are quite unaltered, so that it is probable that the analysis represents very well the composition of the fresh rock. This, made on the freshest piece obtainable at the quarry of Signor Ireneo Capelli, is given in I.

	I	II	III	IV	V	VI	VII	VIII
SiO_2	56·39	55·69	56·19	58 21	41·43	53·70	57·37	55·17
TiO_2	2 07	trace	0·69	trace	0·29	1·92	----	----
Al_2O_3	12·88	19·08	16·76	19 90	9·80	11·16	13·84	13·49
Fe_2O_3	2·36	4·07	3·05	4·07	3·28	3·10	2·44	3·10
FeO	3·54	3·26	4·18	0·87	5 15	1·21	3·44	3·55
MnO	trace	trace	0·10	trace	----	0·04	trace	0·39
MgO	7·83	3·41	3·79	0·98	13·40	6·44	6 05	8·55
CaO	4 06	6·87	6·53	3·58	16 62	3·46	5·53	3·15
Na_2O	1·30	2·89	2·53	2·57	1·64	1·67	1·53	4·43
K_2O	7 84	4·41	4·46	9·17	7 40	11·16	4·47	1·09
$H_2O(110°-)$	1·33	0·17	0·34	0·74	1·11	0·80	3·17	4 27
$H_2O(110°+)$			0·66			2·61		
P_2O_5	----	----	0·55	----	none	1·75	0·37	----
CO_2	----	----	----	----	----	----	0·67	3·27
	99·60	99·85	100·02*	100·09	100·12	100·40†	100·01‡	100·46

I. Selagite ("Mica-trachyte"), Monte Catini, Tuscany. Washington anal.
II. Biotite-vulsinite, Monte Santa Croce, Rocca Monfina. Washington anal. Jour. Geol., v, p. 252, 1897.
III. Augite-latite, Table Mountain, Sierra Nevada, Cal. Hillebrand anal. Turner, 14th Ann. Rep. U. S. G. S., p. 491, 1894.
IV. Vulsinite, Bolsena, Washington anal. Jour. Geol., iv, p. 552, 1896.
V. Venanzite, San Venanzo, Umbria, Rosenbusch, op. cit. infra., p. 113.
VI. Wyomingite, Leucite Hills. Hillebrand anal. Cross, this Journal, iv, p. 130, 1897.
VII. Minette, Kirschhäuser Thal, Odenwald, Lepsius in Zirkel, Lehrbuch, ii, p. 349, 1894.
VIII. Verite, Osann anal., Zeit. deut. Geol. Ges., xli, p. 311, 1889.

The noteworthy features of this are the medium SiO_2, high MgO, K_2O and TiO_2, moderate CaO and low Al_2O_3 and Na_2O. Its essentially monzonitic or latitic character, and the resem-

* Including 0·19 BaO and trace of SrO.
† Including 0·04 Cr_2O_3, 0·62 BaO, 0·19 SrO, 0·06 SO_3, 0·03 Cl, and 0·44 F.
‡ Including 1·13 FeS_2 and trace SO_3.

blance to some analyses of minettes are at once evident, though these last usually show less silica. It may be noted in this connection that Rosenbusch* has already spoken of it as "a younger equivalent of certain minettes." The nearest approach to it among the various minette analyses which I have examined is that of Lepsius of a dike in the Odenwald, as given in VI, which, although somewhat decomposed and with notably lower potash, is of essentially the same character. Another rock with which this may be compared† is the verite of Osann (VIII), in which, however, the alkalies are in inverse ratio.

But it is of special interest to compare the rock at present under discussion with others from its own region. That with which it presents the closest analogies are the ciminites,‡ the analyses of which have just been given. Although they differ to a small extent in certain particulars, as in TiO_2, Al_2O_3, CaO and Na_2O, yet the general correspondence is remarkably close. This is of interest since they differ considerably in mineralogical composition, the abundant and prominent biotites of the Tuscan rock being entirely absent in the ciminite, while the latter carries a plagioclase richer in lime, more abundant olivine and orthoclase, and less augite. They form another addition to the growing list of cases of magmas of similar chemical composition solidifying under diverse conditions to form quite different mineral aggregates.

With this may also be compared the so-called biotite-vulsinite of Rocca Monfina, the analysis of which is given in II. This has been described elsewhere,§ but it may be recalled that it is composed of alkali-feldspar and labradorite, biotite and diopside, with no olivine. The analysis, as compared with I, shows higher Al_2O_3 and CaO, and lower MgO and K_2O, standing between those of the Monte Catini rock or the ciminites and those of the vulsinites, one of which is given for comparison in IV. While in II, Al_2O_3 may be a trifle high and MgO a trifle low, yet the analysis corresponds so well with the appearance of the rock in thin section that it may be regarded as quite trustworthy. The absence of olivine correlated with lower MgO is of especial importance. There was sufficient MgO in the selagite magma to allow the formation of olivine after the crystallization of the biotite, while in the biotite-vulsinite the early formation of this mineral and augite used up all the available supply. As regards the olivine-bearing ciminites, attention has already been called to the fact that

* Rosenbusch, Neues Jahrb., 1880, ii, p. 206.

† Rosenbusch (Elem. Gesteinslehre, 1898, p. 301) has already noted the resemblance between the two rocks.

‡ The probability of this close resemblance has been already suggested. (Jour. Geol., v, p. 354, 1897.)

§ Jour. Geol., v, p. 251, 1897.

in effusive magmas the potential biotite molecule seems to tend to split up, yielding olivine and orthoclase,* which would explain the main differences between the ciminite and selagite.

Indeed, we have in these rocks excellent illustrations of this tendency of the complex biotite molecule to crystallize as biotite in intrusive masses, while it splits up into olivine and either orthoclase or leucite in extrusive flows. The ciminites are all flows, so far as have been observed, while the chemically identical selagite forms, as has been said, a stock or volcanic neck. Exactly parallel with these are the biotite-vulsinite of Rocca Monfina (II), and the augite-latite of Table Mountain in California (III), which has been described by Turner† and Ransome.‡

The former, rich in biotite and without olivine, forms either a domal eruption which took place in the already eroded or exploded volcano, as was formerly suggested,§ or the last upwelling of lava, which plugged up the conduit of the volcano, and hence solidified under conditions analogous to those obtaining in an intrusive mass. The erosion of this volcano has been so extensive that this is quite possible, and, in view of later observations, seems to me the more probable. The latter rock is composed essentially of labradorite, augite and olivine, and a glass, which, from the analysis, would have crystallized largely as orthoclase and is quite free from biotite. The extremely close parallelism of the two analyses is certainly remarkable, and strongly suggestive of this idea, that the diverse mineralogical compositions were determined by diverse conditions of solidification.

Another rock of interest in this connection is one from San Venanzo in Umbria, recently described by Sabatini‖ under the name of venanzite, and later by Rosenbusch,¶ who calls it euktolite. It is an effusive, olivine-melilite-leucite rock, with accessory biotite. The analysis, as given by Rosenbusch, is reproduced in V. Although the venanzite is mineralogically quite different, and chemically much more basic, yet the close analogy between the two will be evident on comparing the analyses. They both show the same features of low Al_2O_3 and Na_2O, and high MgO, CaO and K_2O; i. e., in their general characters they are both monzonitic, or theralitic, as Rosenbusch prefers to call it.

* Iddings, Bull. Phil. Soc. Wash., xii, pp. 166, 172, 1892; Bäckström, Geol. För. Förh., xviii, p. 155, 1896; Pirsson, Jour. Geol., iv, p. 687, 1896; Washington, Jour. Geol., v, 359, 1897.

† Turner, 14th Ann. Rep. U. S. G. S., p. 491, 1894.

‡ Ransome, this Journal, v, p. 361, 1898.

§ Jour. Geol., v, p. 244, 1897.

‖ Sabatini, Boll. R. Com. Geol. Ital., 1898.

¶ Rosenbusch, Sitz. ber. Berlin, Akad., vii, p. 110, 1899.

The close correspondence, chemically, of venanzite with the madupite of the Leucite Hills in Wyoming was pointed out by Rosenbusch, and it is very interesting to observe that the analysis of selagite is very similar to those of wyomingite and orendite from the same region. An analysis of wyomingite is given in VI, and, although a little lower in SiO_2 and Al_2O_3, and considerably higher in K_2O, yet the general chemical resemblance between the two magmas is obvious. Wyomingite, it will be recalled,* is composed of leucite, phlogopite and diopside, and hence differs considerably from the selagite in mineralogical composition.

It may seem at first sight that, since the wyomingite is at the same time a flow and rich in phlogopite, this analogy in chemical composition militates against the views on the splitting up of the biotite molecule which have just been expressed. Examination of the analyses involved, however, shows that, while that of wyomingite is similar in general character, it differs from the others in important particulars. It is, especially as compared with the ciminite analysis given on page 44, lower in SiO_2, Al_2O_3, and at the same time very much higher in K_2O. The consequence of this would be that as there was not enough Al_2O_3 to satisfy all the K_2O, the surplus of this conditioned the formation of the potash-mica, phlogopite.

As an instance of the complexity of these problems the case of the biotite-augite-latites may be mentioned, which have been described by Ransome in the paper cited above. While these also resemble in general features the other analyses, yet they differ in the much higher content of SiO_2, this being 61 to 66 in analyses quoted by him.† Here we have, apparently, the additional factor introduced of the tendency of biotite to form in the more acid magmas, while augite forms in the more basic, but otherwise analogous, magmas.

It is evident from the foregoing that the name of mica-trachyte is a misnomer, both chemically and mineralogically, and that andesite is equally inappropriate. While the rock is chemically equivalent to the ciminites, yet the abundant biotite, which gives it a characteristic lamprophyric appearance, serves to distinguish it sharply from these, and at the same time its more basic composition and content of olivine separate it from the vulsinites. It would seem then advisable to revive for it Haüy's old name of selagite, meaning thereby a latitic rock, of lamprophyric appearance or structure, composed essentially of alkali and soda-lime feldspars, biotite, diopside and olivine, and with a chemical composition approximating to that

*Cf. Cross, this Journal, iv, p. 138, 1897. He remarks on its lamprophyric character.

†Ransome, op. cit, p. 363.

of the analysis here given. It might also, with propriety, be called a minette, though it is rather acid for this, and the name is at present generally applied to rocks occurring in dikes.

Andesite, Radicofani, Tuscany.—Northeast of Lake Bolsena, and east ot Monte Aniata, there rises through the Pliocene marls a volcanic plug or neck, which forms a steep hill, crowned with a ruined castle, and with the small village of Radicofani at its southern foot. It resembles very much the volcanic necks of Uvalde County, Texas, as described by Hill and Vaughan.*

The neck is composed for the most part of a dense black, basaltic-looking rock, which is light gray and andesitic in places, while at the top of the hill it is reddish and highly vesicular.† A columnar structure is shown here and there, but it is not highly developed. The accumulation of talus at its base absolutely forbids any study of the contact, but no signs of metamorphism were visible in the marls outside the talus slope.

The locality and the rock have been described by vom Rath,‡ Bucca§ and Mercalli,‖ but a short account of my specimens will not be out of place. Megascopically the predominant dark variety is black and aphanitic, with some scattered minute phenocrysts of diopside. The lighter kind, which occurs in less quantity, is rather pale gray, also dense, and shows small, yellowish phenocrysts of diopside and olivine. It has the appearance of being a bleached facies of the darker kind, but the results of the analyses do not bear out this supposition.

In thin section little difference is observable between the two varieties. They are both basaltic in structure, and show crystals and fragments of pale green or colorless diopside, some labradorite, and rare crystals and fragments of olivine, lying in a groundmass of diopside grains, labradorite laths, magnetite and apatite, with some leptomorphic orthoclase (?), and interstitial, brown globulitic glass.

An analysis was made of specimens of each variety, and the results are given in I and II. They are not entirely satisfactory, both summing up too high, and there seems to be a small constant error, which I am not able to place without duplicate analyses, for which time is lacking. They must, however, represent fairly well the composition of the rocks, and are interesting in being almost identical, so much so as to pass muster for duplicates. This was somewhat surprising in view of their quite different megascopic appearance, but the study of thin

* Hill and Vaughan, 18th Ann. Rep. U. S. G. S., p. 202 and pl. xxii, 1898.

† This summit scoria is largely used in the country round about for scraping the hair off of pig skins, and is hence rapidly disappearing.

‡ Vom Rath, Zeitschr. d. d. geol. Ges., xvii, p. 405, 1865.

§ Bucca, Boll. R. Com. Geol. Ital., 1887, p. 274.

‖ Mercalli, Atti Soc. Ital. Sci. Nat., xxx, 1387.

sections showed that it was to be expected. In their general features they resemble analyses of andesites, though possibly somewhat basic, and in this way approaching the basalts. It has been noted also that olivine is rare. The alkalies amount to somewhat more than five per cent, and K_2O molecularly is higher than Na_2O, though not as much so as in most other Italian rocks. The analyses do not differ radically from the older ones of vom Rath and Ricciardi, which are given for comparison. The large amount of SO_3 in Ricciardi's analyses is surprising, since no noselite could be found.

	I	II	III	IV	V
SiO_2	54·14	54·56	55·00	53·63	55·23
TiO_2	1·23	1·10	----	----	----
Al_2O_3	16·42	16·49	14·38	14·17	14·06
Fe_2O_3	1·69	1·02	----	1·46	5·06
FeO	5·26	5·65	9·29	8·07	4·12
MnO	trace	trace	----	trace	0·57
MgO	8·44	8·57	7·72	7·05	4·00
CaO	8·05	7·95	8 51	8·52	9·34
Na_2O	2·20	2·07	2·25	1·80	2·07
K_2O	3·34	3·35	2·52	2·03	2·43
H_2O	0·56	0·15	0·48	2·01	1·07
P_2O_5	----	----	----	0·93	1·33
SO_3	----	----	----	0·62	0·84
	101·33	100·91	100·15	100·29	100·12

I. Andesite (black), near Castle Gate, Radicofani. Washington anal.

II. Andesite (gray), west of village, Radicofani. Washington anal.

III. Andesite (gray), Radicofani, vom Rath, Zeit. deut. Geol. Ges., xvii, p. 405, 1865.

IV. Andesite (black), Radicofani. Ricciardi anal. Mercalli, Atti Soc. Ital. Sc. Nat., xxx, p. 4, 1887.

V. Andesite (gray), Radicofani. Ricciardi anal. Mercalli, op. cit., p. 8.

I previously* expressed the opinion that these rocks were probably ciminites, but the examination and analysis of the specimens collected since then, the results of which have just been given, show that while they are analogous to them in certain particulars, yet that they should properly be classed with the andesites, which, as well as the basalts, are rarely found on the Italian peninsula. The occurrence is of interest as showing that the Italian latites may shade off into true andesites and basalts, as well as into basic leucitic rocks.

* Jour. Geol., v, p. 355, 1897.

Leucitite, Capo di Bove, Alban Hills.—Of the well-known rocks of the Alban Hills only the analyses made by Bunsen in 1861 have been published.* It was, therefore, thought advisable to make a new analysis of one of these rocks, and for this purpose a fresh specimen collected at the quarries at Capo di Bove, near the tomb of Cecilia Metella, was selected. The rock, a flow from the Alban volcano, is the well known one which is found in all collections, and does not call for a lengthy description. It need only be said that this specimen is composed of leucite, melilite, nephelite, diopside, magnetite, a few flakes of biotite, scarcely any apatite, and no glass.

	I	II	III
SiO_2	45·99	45·93	46·51
TiO_2	0·37	----	0·83
Al_2O_3	17·12	18·72	11·86
Fe_2O_3	4·17	----	7·59
FeO	5·38	10·68	4·39
MnO	trace	----	0·22
MgO	5·30	5·67	4·73
CaO	10·47	10·57	7·41
BaO	0·25	----	0·50
SrO	none	----	0·16
Na_2O	2·18	1·68	2·39
K_2O	8·97	6·83	8·71
H_2O (110°)−	0·45	0·59	1·10
H_2O (110°)+			2·45
	100·65	100·67	99·73†

I. Leucitite, Capo di Bove. Washington analyst.
II. Leucitite, Capo di Bove. Bunsen analyst. Roth. Beitr. Petr., 1869, p. cii, No. 31.
III. Leucitite, Bearpaw Mountain, Montana. H. N. Stokes anal. Weed and Pirsson, this Journal, ii, p. 147, 1896.

The analysis, which resembles closely the older one of Bunsen (II), except as to Al_2O_3 and K_2O, is characterized by high K_2O, CaO and iron oxides, and, for so basic a rock, quite high Al_2O_3 and low MgO. It was thought possible that the same error had been made in the determination of these two oxides which has already been noticed elsewhere. So a second analysis was made recently, which, however, gave results quite confirmatory of those of the earlier one. The figures given above are the means of the two closely agreeing determinations of all the constituents, except H_2O. They may, therefore, be considered reliable.

* Roth. Beitr. Petr. plut. Gest., 1869, p. cii, Nos. 30–33.
† Including 0·80 P_2O_5, 0·04 Cl, 0·04 NiO and traces of CuO, CoO, F and SO_3.

The apparently high Al_2O_3 is largely taken up by the abundant leucite, while the melilite and especially the nephelite also demand quite an amount of it. Owing to the composition of the melilite and diopside a calculation of the mineral composition of the rock is not easy or satisfactory. Assuming, however, that by far the greater part of the K_2O and Na_2O belongs in the leucite and nephelite, it is calculated that leucite makes up about 52 and nephelite about 10 per cent, leaving some 38 per cent of melilite, diopside and magnetite. It is difficult to say exactly how these are distributed, but a rough estimate, combined with the microscopical examination, gives melilite and diopside each about 17 per cent and magnetite about 5 or less.

In the leucitite of Bearpaw Mountain, Montana (III), described by Pirsson,* MgO is also low, though Al_2O_3 is considerably lower than in the Alban rock. The Montana rock, however, is composed only of leucite (57·1 per cent), diopside (31·1 per cent) and magnetite (11·8 per cent), and contains neither nephelite nor melilite.

Comparison of these analyses with that of venanzite given on a preceding page is of interest. The lower SiO_2 and Al_2O_3 and higher MgO in this latter have conditioned the abundant olivine and considerable biotite, both of which are wholly absent in the leucitite. The nepheline of the latter at the Alban Hills is, conversely, lacking in the venanzite.

In this connection I would express my complete agreement with Dr. Cross† in his suggestion that "the term leucitite be reserved for the rock which has not yet been discovered, consisting essentially of leucite, with all other minerals of subordinate importance. There is good reason to believe that such rocks are possible and will be found at no distant day. The same suggestion is made for nephelinite, on the same grounds."

Following out this idea it is evident from the above estiment of the mineralogical composition of the Capo di Bove rock, however crude it may be, that the term leucitite is not quite appropriate. The same would hold true of the term as applied to any of the Italian or other leucitites so far as known. The present is not the place for any discussion, nor for the bestowal of new names, but the fact is obvious that a critical revision and reclassification of all the leucitic rocks is highly desirable.

Locust, N. J., November, 1899.

* Weed and Pirsson, this Journal, ii, p. 143, 1896.
† Cross, this Journal, iv, p. 137, 1897.

Art. VII.—*The Constitution of the Ammonium Magnesium Arseniate of Analysis;* by Martha Austin.

[Contributions from the Kent Chemical Laboratory of Yale University—XCII]

The striking analogy between the phosphates and the arseniates led Levol* to undertake the separation of an ammonium arseniate corresponding to the ammonium magnesium phosphate, the composition of which Berzelius had given. Levol states that ammonium magnesium arseniate of the composition $NH_4MgAsO_4.10H_2O$ is obtained by adding a solution of a double ammonium magnesium salt to arsenic acid, and that it is a salt possessing about the same degree of solubility in water, in ammoniacal water, and in ammoniacal water containing magnesium salt, as the corresponding phosphate. Further, he found that by heating this salt to red heat after carefully drying, magnesium pyroarseniate was given, from which arsenic can be estimated readily.

Wach† and H. Rose‡ obtained the ammonium magnesium arseniate containing six molecules of water of crystallization by precipitating arsenic acid with magnesia mixture and then adding an excess of ammonia, and by drying at 100° C. were able to estimate the arsenic present as the ammonio-magnesium arseniate containing one-half molecule of water. This method seemed to offer an advantage over the method of estimation as the pyroarseniate, for results obtained below the theoretical amount of arsenic present gave rise to the suspicion that during ignition arsenic was reduced by the ammonia driven off. Rose attempted in another way to avoid this loss by igniting in a current of oxygen; and later Reichel‡ ignited the residue after carefully saturating it with ammonium nitrate and nitric acid, and drying at 100° C. Rammelsberg§ believed that it was safer to ignite after drying at 120° C. because drying at 100–110° C. caused a loss of ammonia before ignition. Kaiser¶ dried the residue in a current of air.

A second source of error discussed by H. Rose,** Fresenius and others is due to the solubility of the ammonium magnesium arseniate in water, in ammoniacal water, and ammoniacal water containing magnesium salts. Wood†† attempted to avoid this by precipitating the ammonio-magnesium arseniate with an alcoholic magnesia mixture, and by washing the precipitate with an alcoholic solution, by weighing the residue

* Ann. de Chim. et de Phys., III, xvii, 501, 1846.
† Schweigger, Journ. f. Ch. u. Phys., lix, 297.
‡ Ann. d. Phys., lxxvi, 20.
§ Ber. d. d. Chem. Gesell., xiv, 279.
‖ Ber. d. d. Chem. Gesell., vii, 544.
¶ Zeitschr. f. Anal. Chem., xiv, 250.
** Zeitschr. f. Anal. Chem., iii, 206.
†† This Journal, III, vi, 368.

ignited in a crucible held in a second protecting crucible, after treating with nitric acid and ammonium nitrate, he obtained concordant results. Brauner* followed this method with success.

As has been shown by Dr. Hugo Neubauer,† ammonium chloride tends to form a phosphate of magnesium too rich in ammonia, and in papers‡ from this laboratory it has been shown that the tendency of ammonia and ammonium chloride is to cause the replacement of some of the metal in the ammonium phosphate of manganese, of magnesium and of other metals in the second group of Mendeléeff, giving phosphates too rich in ammonia for the ideal constitution. The marked similarity as to behavior between the phosphates and the arseniates led to the investigation of the constitution of the ammonium magnesium arseniate under the usual conditions imposed in analysis, and, further, to the effect of ammonium chloride on the salt of ideal constitution.

In the table which follows are recorded a set of qualitative tests, in which the hot filtrates were tested by hydrogen sulphide in presence of hydrochloric acid. These tests were made to show under what conditions of volume, given amounts of arsenic acid can be entirely removed by magnesia mixture from ammoniacal solutions alone, or from ammoniacal solutions containing ammonium chloride. The ammonium chloride for this work was carefully purified by heating it to boiling temperature in concentrated solution — 1 grm. to 3^{cm^3} — with ammonia in slight excess. The magnesia mixture was prepared by dissolving one hundred and ten grams of the crystallized magnesium chloride in a small volume of water, filtering and adding to it fifty-eight grams of ammonium chloride in solution, purified by adding bromine water and bleaching with ammonia, filtering and then diluting to a volume of two liters, adding enough ammonia—10^{cc}—to make this solution smell distinctly of ammonia.

The results (1) to (3) recorded in the table were obtained by precipitating the arsenic present in solution by means of the magnesia mixture prepared as described and rendering the solution distinctly ammoniacal. After standing until the precipitate subsided, the solution was filtered and tested for arsenic by hydrogen sulphide. Within certain limits of volume all the arsenic is removed from solution by the magnesia mixture. In case of (3) two additional amounts of the precipitant had to be made in order to remove the arsenic, the

* Zeitschr. f. Anal. Chem., xvi, 57.

† Zeitschr. f. Anorg. Chem., ii, 45; iv, 251; x, 60. Zeitschr. f. Angen Chem., 1896, 435. Jour. Amer. Chem. Soc., xiv, 289.

‡ This Journal, vi, 233; vii, 187; viii, 206.

solution being ammoniacal. Results (4) to (10) of the table were obtained in the same manner as (1) to (3), the amount of arsenic acid present being increased ten times. In (9) and (10), where the smaller amounts of magnesia mixture were used,

TABLE I.

	Volume. cc.	Arsenic present in terms of As_2O_5. grm.	Magnesia mixture. cc.	NH_4OH. cc.	NH_4Cl. grm.	Indications of arsenic in the filtrate by H_2S.
(1)	100	·05	20	slight excess	--	none
(2)	200	·05	20	" "	--	"
(3)	300	·05	I 20	" "	--	I present
			II 20			II present
			III 20			III none
(4)	200	·5	50	" "	--	none
(5)	300	·5	50	" "	--	present
(6)	300	·5	50	2	--	"
(7)	200	·5	50	4	--	"
(8)	200	·5	30	2	--	present
(9)	200	·5	I 30	4	--	I present
			II 10			II none
(10)	100	·5	I 30			I present
			II 10	2	--	II none
(11)	130	·5	50	excess	10	present
(12)	200	·5	50	"	10	"
(13)	150	·5	75	"	10	none
(14)	250	·5	75	"	10	present
(15)	300	·5	75	2	10	trace
(16)	400	·5	75	2	10	present
(17)	285	·5	100	excess	10	none
(18)	215	·5	100	"	20	none
(19)	335	·5	100	"	60	present
(20)	360	·5	125	"	60	present
(21)	360	·5	150	"	60	none

additional portions had to be added before all the arsenic was removed from solution. When the larger amounts of ammonia were used the results did not seem to be influenced, (7) and (9). The results recorded in (11) to (21) were obtained by precipitating the arsenic in solution in presence of ammonium chloride by the magnesia mixture. It is evident that the presence of ammonium chloride causes some arsenic to be dissolved and further that this solvent effect is overcome by the magnesia mixture added in larger amounts, even when the ammonium chloride present amounts to sixty grams in weight, as in (21).

In order to find how much arsenic is dissolved from the ammonium magnesium arseniate once precipitated so that no arsenic is left in solution, experiments were made in which the arsenic in the filtrate was weighed after precipitating by hydrogen sulphide in hot acid solution, filtering off on asbestos under pressure, washing successively with water, alcohol, carbon disulphide, alcohol, and water, and drying at 100° C.

TABLE II.

H_2O containing 1cc NH_4OH in 200cc. grm.	NH_4OH S. G. 0·96. cc.	As_2O_5 digested. grm.	As_2O_5 found as As_2S_3. grm.
---	100	0·5	0·0019
---	100	0·5	0·0026
100		0·5	0·0003
100		0·5	0·0005
10		0·5	0·0002
10		0·5	0·0004

It is evident from these qualitative tests that, so far as concerns the amount of arsenic dissolved from the ammonium magnesium arseniate, it is safe to use a faintly ammoniacal washwater in small amounts—less than 100cc—to remove traces of reagents from the residue after it is gathered upon the asbestos felt. Usually 25–50cc of washwater were used in rinsing off the precipitate in the experiments about to be given below.

The solution of arsenic employed in this work was prepared by dissolving ten grams of pure arsenious oxide, carefully resublimed, in a platinum dish in an excess of pure nitric acid and evaporating on the waterbath to dryness, dissolving the arsenic acid produced in water and diluting to a volume of one liter in a standard flask.

Definite portions of this solution were drawn from a burette into a platinum dish and precipitated with magnesia mixture prepared as described in the proportion shown necessary by the qualitative tests for the complete removal of the arsenic from solution, and the solution was made distinctly ammoniacal. The precipitate, dissolved in hydrochloric acid in slight excess, was brought down again by ammonia in distinct excess. After standing until the precipitate had completely subsided, the precipitate was gathered on an asbestos felt in a perforated platinum crucible, making use of the filtrate to remove the last portions of the precipitate to the felt, before washing any reagents from it on the felt with faintly ammoniacal water. After carefully drying, the residue was ignited to the pyroarseniate. The results shown in A fall so far below the theory for magnesium arseniate that it seems evident that the arseniate

shows a tendency here to form a salt richer in ammonia than the ideal $MgNH_4AsO_4$, and yielding on ignition some meta-arseniate instead of the normal pyroarseniate. In section B the magnesium ammonium arseniate was precipitated by adding to the solution of arsenic acid magnesia mixture containing no free ammonia in the proportion necessary (50^{cm^3}) to remove the arsenic from solution, and then making the solution distinctly ammoniacal. After the precipitate had subsided, it was filtered off on asbestos under pressure in a perforated platinum crucible, washed on the felt with ammoniacal water, dried and ignited. These results are also below the theory for the pyro-arseniate. Evidently the conditions here are even better for the formation of the salt too rich in ammonia than they were in the first case. No arsenic was found by hydrogen sulphide in any case either in the filtrate or in the washwater after acidifying and heating.

TABLE III.

	$Mg_2As_2O_7$ corresponding to As_2O_5.			
	Taken. grm.	Found. grm.	Error. grm.	As_2O_5 found by H_2S in the filtrate.
A	0·7843	0·7800	0·0043—	none
	0·7843	0·7794	0·0049—	none
B				
	0·7843	0·7772	0·0071—	none
	0·7843	0·7769	0·0074—	none

In section A of Table IV the results recorded were obtained by precipitating definite portions of arsenic acid drawn from a burette into a platinum dish with the distinctly ammoniacal magnesia mixture in proper proportion, and afterward adding a little more ammonia, filtering off on asbestos under pressure in a perforated platinum crucible as soon as the precipitate subsided, washing off on the felt with ammoniacal water any of the reagents left on the precipitate in transferring it to the felt by using the filtrate, drying and igniting. No arsenic was found in any case in the filtrate or in the washwater by hydrogen sulphide. The conditions of precipitation here prove to be such, as the results show, that the salt of ideal constitution is formed. Comparing these results with those of Table III, it seems that the conditions under which the salt of ideal composition is formed are such that at the moment and in the locality of precipitation the amount of magnesium chloride in a certain volume of solution must be large in proportion to the amount of ammonia present as the chloride and the hydroxide; otherwise the ammonium of the ammonium arseniate, naturally formed first, does not suffer sufficient displacement by magnesium to produce the normal ammonium magnesium arseniate.

At all events, the treatment applied in the experiments of A resulted practically in the complete precipitation and in the production of a precipitate of nearly ideal constitution.

TABLE IV.

	$Mg_2As_2O_7$ corresponding to As_2O_5.					
	Taken. grm.	Found. grm.	Error. grm.		Magnesia mixture. cc.	NH_4Cl. grm.
				A		
(1)	0·7843	0·7830	0·0013—		50	--
(2)	0·7843	0·7849	0·0006—		50	--
(3)	0·7843	0·7841	0·0002—		50	--
(4)	0·7843	0·7843	0·0000—		50	--
				B		
(5)	0·7843	0·7763	0·0080—		75	10
(6)	0·7843	0·7762	0·0081—		75	10
(7)	0·7843	0·7832	0·0011—		100	10
(8)	0·7843	0·7838	0·0005—		100	10
(9)	0·7843	0·7784	0·0059—		100	20
(10)	0·7843	0·7810	0·0033—		100	20
(11)	0·7843	0·7849	0·0006+		150	60
(12)	0·7843	0·7846	0·0003+		150	60

In section B of the same table the results recorded show the effect of increased amounts of ammonium chloride on the constitution of the ammonium magnesium arseniate. Enough magnesia mixture was used in each case to remove the arsenic completely from solution. The precipitates were gathered on asbestos in a perforated platinum crucible and treated as those described in section A of the table. It is evident as shown by (5) and (6) of the table that ammonium chloride causes a replacement of some of the metal by ammonia in the ammonium magnesium arseniate (to form, possibly, a salt of the constitution $Mg(NH_4)_4AsO_4$) though the solvent effect of the ammonium chloride is overcome by the addition of a sufficient amount of magnesia mixture. No arsenic appeared in the filtrates, and, further, experiments (7) and (8) show that increasing the amount of magnesia mixture present will cause the formation of the salt of ideal constitution even in presence of considerable amounts of ammonium chloride. Indeed this is possible where as large an amount as sixty grams of the salt is present, as results (11) and (12) show. Obviously, ammonium chloride in any amount above what is required for the magnesia mixture tends to dissolve the precipitate, but this solvent effect may be neutralized by increasing the amounts of magnesia mixture even though the precipitate formed is richer in ammonia than the ideal salt.

In no one of the many precipitates tested by silver nitrate for included chlorides was more than an inappreciable trace found.

Evidently, when ammoniacal magnesia mixture, amounting to about thirty cubic centimeters in excess of the theoretical amount necessary to precipitate all the arsenic as the ammonium magnesium arseniate, is added to the faintly acid solution of arsenic acid (carrying no ammonium salts) in a volume not exceeding two hundred cubic centimeters, the precipitate appears to fall in ideal condition. If the precipitated salt is transferred to the filtering crucible by the aid of portions of the filtrate used as the washing liquid and finally washed on the asbestos with about twenty-five cubic centimeters of faintly ammoniacal water—an amount which is quite sufficient after the transfer has been made—no arsenic gets into solution. The weight of the carefully dried and ignited pyroarseniate indicates with accuracy the amount of arsenic present.

I wish here to thank Professor F. A. Gooch for the help and advice he has constantly given throughout this work.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Use of the Method of Limiting Density in recalculating Atomic masses.*—It has been shown by D. Berthelot that the molecular masses of gases are proportional to their densities at infinitely small pressures and hence that they may be calculated from data derived from compression. Results thus obtained for the atomic masses of hydrogen, nitrogen and carbon, as calculated from the limiting density of their oxides, are in good agreement with those obtained by chemical methods. More recent results give for carbon 12·0025 from acetylene, 12·000 from carbon dioxide and 12·007 from carbon monoxide; the most probable value being 12·005. For nitrogen 14·000 from nitrous oxide, the probable value being 14·005. For argon, from Rayleigh's values, molecular mass 39·882. For chlorine 35·479 from hydrogen chloride, identical with Stas's value if 107·912 be accepted for silver. For sulphur, 32·046 from sulphur dioxide, Stas's result being 32·045. It would appear, therefore, that the physical method as devised by the author is capable of great accuracy.—*C. R.*, cxxvi, 1501–1504, 1898. G. F. B.

2. *On the Newly Discovered gases and their Relation to the Periodic Law.*—A lecture on the new gases of the atmosphere has been delivered by Ramsay before the German Chemical Society. Deeming it possible that a group of elements may exist between the nitrogen group and the lithium group of the periodic system, such as He = 4, ? = 20, A = 40, the author examined 15 liters of argon, liquefied in a Dewar's tube by means of boiling liquid air, and giving 25^{cc} of a clear liquid having some solid flakes floating in it. On allowing the pressure on the boiling air to rise, the argon boiled off, the least volatile part being collected apart. This he calls *metargon*, though it has not been obtained free from argon, and has been but little studied. The first most volatile fraction, on cooling in liquid air, only partially liquefied. The remaining gas contained a new constituent which he called *neon*, though it was mixed with helium and argon. Purified as far as possible it had a density of 10·19, and a refractive power of 0·388. Its spectrum gave lines in the red of wave length 6402, 6383, 6335, 6227, 6218, 6164, 6143, 6096, 6074, 6030; yellow (D_3) 5853; green 5401, 5341, 5331; blue 4716, 4722, 4710, 4709, 4704. If 1·67 is the ratio of its specific heats, its atomic mass is 20, corresponding to the missing element of the above group. On collecting separately the last portions of gas from the liquid air used for liquefying the argon, it was found to have a density of 22·5, a specific heat ratio of 1·66, and to give spectrum lines in the red, yellow and green (5570). This gas he called *krypton*. Still another gas, accompanying argon in air, obtained, however,

only in an impure state, had a density of 32·5 and was called *xenon*. It could not be detected in the 15 liters of argon, but only in the large quantities of liquid air used. It has several lines in its spectrum but none are brilliant.—*Ber. Berl. Chem. Ges.*, xxxi, 3111–3121, Dec., 1898. G. F. B.

3. *On the Preparation of Calcium and Calcium hydride.*—By the electrolysis of anhydrous calcium chloride in a graphite crucible containing a porous cell VON LENGYEL has obtained metallic calcium. The positive electrode was placed in the crucible and the negative in the porous cup, a current of 10–18 amperes under a pressure of 70–110 volts being employed. On placing the regulus obtained in anhydrous ether a product is obtained containing 99·2 per cent of calcium. The metal has a density of 1·5540 at 18°, resembles in color a gold alloy rich in silver, is not affected by cold dry air, but burns brilliantly at a red heat. It unites at ordinary temperatures with hydrogen to form the hydride CaH_2, the action being very energetic at a red heat. This hydride is a grayish earthy substance which decomposes water even more readily than the metal, the hydrogen often inflaming, and burns brilliantly in oxygen at a red heat.—*Chem. Centralbl.*, ii, 262, 1898. *J. Chem. Soc.*, lxxvi, ii, 218, April, 1899. G. F. B.

4. *On Non-explosive Decomposition.*—It has been pointed out by HOITSEMA that rapid and slow decompositions in some cases yield products which are identical, while in others the reverse obtains. Since gun-cotton belongs to the latter class of substances, no explosion-velocity experiments are possible. At about 150° it can be slowly decomposed without explosion, evolving gases containing a little N_2O_4 and leaving a non-explosive peat-like mass containing about 7 per cent of nitrogen. Higher nitrogen oxides do not appear to result from secondary reactions, since it is easy to prove by special apparatus that they precede the formation of nitric oxide. It would seem, therefore, that these higher oxides are due to impurity, or are produced only in the initial stages of the reaction. Ordinarily the stability of a gun cotton is determined by observing the time elapsing before nitric fumes are evolved at a fixed temperature. In the author's apparatus the explosive may be maintained at any desired temperature for any length of time. Hence he thinks it better to ascertain the highest temperature at which the sample may be kept for a quarter of an hour or so without emitting nitrous fumes.—*Zeitschr. physikal. Chem.*, xxvii, 567–578, Dec., 1898. G. F. B.

5. *On Crystalline Liquids.*—It is well known that two views are held on the subject of crystalline liquids; the one by Lehmann who regards them as crystals of remarkably small viscosity, the other by Quincke who maintains that they consist of a multitude of minute solid crystallites each enclosed in a thin liquid film. SCHENCK has pointed out that if the latter supposition be true, the liquid crystals not being homogeneous, then different transition temperatures ought to be found for different preparations and for the products crystallized from different solvents. To test

the matter he crystallized parazoxyanisoil from (*a*) acetone, (*b*) alcohol and (*c*) chloroform. As he was unable to detect any appreciable change of the transition-point, he concludes that the view of Lehmann is the more probably correct. It has been pointed out by Ostwald that the stability-interval of crystalline liquids must be near the critical point for solid and liquid; i. e., near the temperature at which the heat of fusion is zero. By means of the specific heats of the crystalline and the isotropic liquids, the difference between the transition and critical temperatures is calculated as (1) 27·6° and (2) 18·4°. The difference in these values may perhaps be due to dimorphism of the compound. Hence the author considers desirable further determinations with other compounds.—*Zeitschr. physikal. Chem.*, xxviii, 280–288, March, 1899. G. F. B.

6. *On the Density of Liquid Air, and of other liquefied Gases.*—Experiments have been made by Ladenburg and Krügel to determine the density of liquefied air and other gases. For this purpose they made use of glass rods, whose density had been carefully determined by weighing in air and in water at 4°. By means of a Mohr's balance these rods were carefully weighed in the liquefied gases, the decrease in weight being accurately noted. No correction was made for the buoyancy of the atmosphere, and none for the contraction in volume of the glass, as its coefficient for these low temperatures was not known. In the case of liquid air the authors determined simultaneously its composition. They found (1) that freshly liquefied air had a density of 0·9951, and contained 58·83 per cent of oxygen. (2) That after several hours, the density increased to 1·029, when it contained 64·2 per cent of oxygen. (3) That after standing for 2 or 3 days until most of the nitrogen had evaporated, the density rose to 1·112, there being present in it 93·6 per cent of oxygen. The authors, therefore, conclude that the density of a liquid containing 20·9 per cent of oxygen would be 0·87–0·90. Liquid oxygen pure has a density slightly lower than the above mentioned mixture containing 93·6 per cent of it, being 1·105–1·108. The fusing point of ethylene was found to be −169° and the boiling point −105·4° at 760^{mm} pressure; the values given by Olszewski being the same for the fusing point but −102·5° for the boiling point. The density of the liquid at −169° was noted as 0·6585 and at −105·4°, 0·571.—*Ber. Berl. Chem. Ges.*, xxxii, 46–49, 1899. G. F. B.

7. *Leçons de Chemie Physique*, professées à l'Université de Berlin. Par J. H. Van't Hoff, Professor ordinaire à l'Université. Traduit de l'allemand par M. Corvisy. Deuxième Partie. La Statique Chimique. 8vo, pp. 162. Paris, 1899 (Hermann).—This is the second part of Professor Van't Hoff's Berlin lectures, the first part having been noticed in this Journal for February, 1899, p. 157. G. F. B.

8. *Lehrbuch der Allgemeinen Chemie;* von Dr. Wilh. Ostwald. Zweite umgearbeitete Auflage in zwei Bänden. Zweiten Bandes Zweiter Teil. Verwandtschaftslehre, Vierte Lieferung,

Bogen 39–52 mit figur 71–152. Leipzig, 1899 (Engelmann).—An additional part of this most valuable treatise of Ostwald on General Chemistry. G. F. B.

9. *Grundriss der Allgemeinen Chemie;* von W. Ostwald. Dritte umgearbeitete Auflage. 8vo. pp. xvi, 549. Leipzig, 1899 (Engelmann).—This excellent abridgment of Professor Ostwald's larger work has proved so useful to the chemical student that a third edition will be warmly welcomed. The revision has been thorough and considerable new matter has been added. G. F. B.

10. *Laboratory Manual.* Experiments to illustrate the Elementary Principles of Chemistry; by H. W. Hillyer, Ph.D. 8vo, pp. vi, 200. New York, 1899 (The Macmillan Co.).—This book is designed for the use of college students in general chemistry, the odd pages being left blank for notes. Part I comprises the preparation and properties of the elements and their compounds, and Part II, the verification of quantitative laws. It seems to have been carefully compiled. G. F. B.

11. *Strahlung und Temperatur der Sonne;* von Dr. J. Scheiner, Professor der Astrophysik an der Universität Berlin. 8vo, pp. iv, 99. Leipzig, 1899 (Engelmann).—A valuable contribution to the solar radiation question, giving the latest results of the best observers. In an appendix the diameter of the sun is discussed. G. F. B.

12. *Influence of small impurities on the spectrum of a gas.*—The difficulties in obtaining pure gases for spectrum analysis are well known to physicists. These gases are necessarily contained in glass tubes or receptacles: and the varying quality and conditions of the glass affect the conditions of the gases, especially when powerful electrical discharges are employed. The preparation of X-ray tubes has brought out forcibly the necessity of heating the glass receptacles repeatedly, and also subjecting them to electrical discharges in order to drive off the adhering layers of air. It is probable that one never succeeds in freeing the glass entirely from aqueous vapor. Indeed grave doubts exist whether many of the spectral lines attributed to a gas—for instance, hydrogen—are really lines of the pure gas. Mr. P. Lewis has investigated the influence on the spectrum of hydrogen and other gases of small impurities. The gases were in electrodeless tubes, in order to avoid the questions of the absorption of the gases by metals. He found that a small quantity of oxygen in hydrogen increased the brilliancy of the hydrogen spectrum—the mercury vapor spectrum appeared to strongly diminish the brilliancy of the hydrogen spectrum. Mr. Lewis is of the opinion that the mixed spectrum of hydrogen—the white spectrum and the characteristic line spectrum which appears strongly when a Leyden jar is used—is a real hydrogen spectrum. In electrodeless tubes the hydrogen spectrum is brightest at about 3^{mm} pressure; and in electrode tubes at $0{\cdot}6^{mm}$. In a pure oxygen atmosphere the spectrum of mercury vapor arising from the pump was not present; a small trace of hydrogen brought out the green

line of hydrogen. The influence of mercury at very low temperatures was also investigated. The paper is a valuable contribution to spectrum analysis.— *Wied. Ann.*, No. 10, 1899, pp. 398–425. J. T.

13. *On the limit of hearing.*—RUDOLPH KOENIG in an opening article discusses this question, whether the upper limits set by various authors, c^6 to c^7 or c^8, is a true one. On account of the psychological questions involved in taking what may be called hearsay evidence—of observers—Koenig resolved to study the subject by means of Kundt's dust figures. The paper contains numerous plates of the results obtained, which are remarkable from an experimental point of view, and the author promises a continuation of his paper.— *Wied. Ann.*, No. 11, 1899, pp. 626–660. J. T.

14. *Rotating bodies in electric fields.*—A. HEYDWEILLER in a long paper discusses the phenomena of the solution of bodies in electric fields of greater and of less conductivity than the bodies. He agrees with certain other investigators in finding evidence of accelerating or retarding forces, due to changes in the electric fields. His investigations lead him to determination of the electrical conductivity of air at different pressures, and he discusses the probable effect of these accelerating or retarding forces on the motion of the sun and planets. It appears to him that the motion of the moon may be appreciably affected by these electrical forces.— *Wied. Ann.*, No. 11, 1899, pp. 531–575. J. T.

15. *Masses of ions in gases at low pressures.*—A very important paper was presented at the late meeting of the British Association at Dover on this subject by Prof. J. J. THOMSON and a fuller account is now published in the Philosophical Magazine. It is believed by the author that the composition of a gas consists in the detachment from the atom of a negative ion; this negative ion being the same for all gases, while the mass of the ion is only a small portion of the mass of an atom of hydrogen. This negative ion, therefore, becomes of the utmost importance in all theories of electrical action, and may be the fundamental quantity in terms of which all electrical process can be expressed. The mass of an atom is not invariable. Electrification of a gas consists in splitting up some of the atoms of a gas. The detached corpuscles act like negative ions; each carrying a constant negative charge, which the author calls the unit charge.

This theory is carefully elaborated and forms the most important contribution to this subject of the present year.—*Phil. Mag.*, Dec. 1899, pp. 547–567. J. T.

II. Geology and Mineralogy.

1. *Coal Deposits of Indiana;* by W. S. Blatchley, State Geologist, pp. 1–1741, Coal maps, A–G, Plates i–xciii, figures 1–986:—Indiana, Department of Geology and natural resources, 23d Annual Report, 1898.—This bulky volume is made up chiefly of a detailed report on the Coal deposits of Indiana (pp. 1–1573). The statistics for this have been gathering during the years 1896–1898, by Dr. Geo. H. Ashley and his assistants, adding greatly to the facts available when the last report on the Coal area was published in 1878. Following this is the Report of the State Inspector of Mines, by Mr. Robert Fisher (pp. 1574–1674). Seventeen counties are stated to be coal-producing, with a total out-put of over five million tons in 1898; an increase of 948–958 tons over the production for 1897. This increase in coal mining is traced to the gradual decrease in gas flow in the state. The closing part is the Annual Report of the Natural Gas Supervisor (pp. 1675–1702), by J. S. Leach, The natural gas is fast being exhausted; the pressure, which was at first 325 pounds to the square inch, is now less than 200 lbs. The following summary of the present condition of the Indiana natural gas field is given:

"1. The gas resources of the territory in the gas field is practically all controlled by territory under lease, either by gas companies or manufacturers, and the pipe line companies, which are the large consumers of natural gas, have extended their lines from year to year and are apparently centering around Fairmount township, Grant county.

"2. The undeveloped territory in the field, that not invaded by pipe lines and having only sufficient wells to supply local consumption, comprises about 150 square miles in Grant, Madison and Delaware counties. Possibly a few square miles in Licking township, Blackford county, should be added to this.

"3. If the yearly extension of pipe lines is as great in the future as it has been in the past, it will not require to exceed two years to completely occupy this territory. It does not follow from what has been said that the natural gas field will be exhausted in two years; for after the field is threatened with pipe lines doubtless many wells will be drilled with results that will justify the expense.

"4. The salt water, that has been a menace to the natural gas interests from the beginning, is becoming more intrusive day by day, there being but few wells in the field entirely free from its influence. Wells apparently free from it when drilled become wet soon after being attached to the line.

"5. Rock pressure does not indicate the productiveness of one well as compared with another, but any material decline of the same indicates a diminution in the supply. The average rock pressure of the undeveloped territory in 1895 was 264 pounds. The average of the same territory at present is 181 pounds, a

decrease of 83 pounds in a little more than three years. The average rock pressure of the entire gas-producing territory, November, 1897, was 191 pounds; November, 1898, the average of the same territory was 173, a decrease of 18 pounds.

"6. The history of other gas fields, the past history of this and all its present conditions, justify the statement that the supply of gas is failing and will finally be exhausted." (pp. 1688–9.)

W.

2. *Geological Survey of Canada*, G. M. Dawson, Director.—The following Reports and Map-Sheets have been recently published:

Annual Report, Vol. X, No. 678. Report on the Geology of the area covered by the Seine River and Lake Shebandowan Map-Sheets, comprising portions of Rainy River and Thunder Bay Districts, Ontario, by William McInnes, pp. 5 H–65 H, plates I–III, 1899.

Maps to accompany Part H, Vol. X (New Series): 560. Seine River Sheet, Thunder Bay and Rainy River Districts, Ontario. 589. Lake Shebandowan Sheet, Thunder Bay District, Ontario.

Annual Report, Vol. X, No. 672. Report on the Geology and Natural Resources of the area included by the Nipissing and Temiscaming Map-Sheets, comprising portions of the District of Nipissing, Ontario, and of the County of Pontiac, Quebec, by Alfred Ernest Barlow, pp. 5 I–302 I, plates I–V, figures 1–4, 1899.

Maps to accompany Part I, Vol. X (New Series): 599. Lake Temiscaming Sheet, Nipissing District, Ontario, and Pontiac Co., Quebec. 606. Lake Nipissing Sheet, Nipissing District, Ontario, and Pontiac Co., Quebec.

Annual Report, Vol. X, No. 662. Section of Mineral Statistics and Mines, Annual Report for 1897, by Elfric Drew Ingall; Assistants, Theo. C. Denis, J. McLeish, pp. 5 S–232 S, geol. map, 1899.

No. 669. Shuswap Sheet (British Columbia). Economic minerals and glacial striæ, by G. M. Dawson, assisted by J. McEvoy, 1898, scale $\frac{1}{253,440}$.

No. 604. Shuswap Sheet, geologically colored. In this sheet the following formations are recognized and defined, viz.:

Upper Volcanic Group (chiefly basalts), Tranquille Beds, etc.,	Miocene.
Coldwater Group,	Oligocene.
Nicola Formation,	Triassic.
Cache Creek Formation, (Marble Canon Limestones ?) Cache Creek Formation, (lower members)	Carboniferous.
Adams Lake Series, Nisconlith Series,	Cambrian.
Shuswap Series, (and foliated granites.)	Archæan.

W.

3. *Dictyospongidæ—A Memoir on the Palæozoic Reticulate Sponges constituting the family Dictyospongidæ;* by JAMES HALL, in collaboration with JOHN M. CLARKE, University of the State of New York, State Museum, Memoir II, pp. 1–350, plates I–LXX, figures 1–45.—This exhaustive monograph on the Paleozoic fossil sponges was begun in the '80's. Professor Hall's first description of nine species of Dictyophyton, in 1863, referred them to the Algæ. In 1881,* Whitfield recognized their spongeous nature; and in 1882, an advanced notice of, and in 1884, a number of plates and descriptive text of a report with nearly the same title as the present volume, were issued by Hall in the Thirty-fifth Annual Report of the State Museum of New York. The 128 species are distributed in seven sub-families, under thirty-two genera. One genus is reported from the Lower Helderberg. The latest species are from the Keokuk group, and the largest number of species and genera are from the Chemung (82 species in 16 genera). The plates are exquisite examples of the lithographer's work. W.

4. *Geological Survey of Alabama.*—A map of the Warrior Coal Basin with columnar section of formation so far as it carries workable coals, prepared by HENRY MCCALLEY (on a scale of 7 miles to 8^{cm}), is issued Nov. 1st by the State Geologist, Eugene A. Smith, anticipating the later printing of the Report. W.

5. *Studies on Cambrian Faunas.*—The following important papers by G. F. MATTHEW are printed in the Transactions of the Royal Society, Canada (1899–1900, vol. v, section iv, pp. 39–139, plates i–viii): No. 3. Upper Cambrian Fauna of Mount Stephen, British Columbia; The Trilobites and Worms. No. 4. Fragments of the Cambrian Faunas of Newfoundland; The Etcheminian Fauna of Smith Sound, Newfoundland, by G. F. Matthew. W.

6. *American Museum of Natural History.*—Catalogue of the types and figure specimens in the Palæontological collection of the Geological Department, American Museum of Natural History, by R. P. WHITFIELD, assisted by E. O. HOVEY, Part II, beginning with the Medina Sandstone, pp. 74–188, has recently been issued under date of Oct. 12, 1899.

7. *Bulletin of the Wisconsin Survey-Building and Ornamental Stones of Wisconsin;* by E. R. BUCKLEY, Ph.D., 8°, pp. 544, Pls. 69. Madison, 1898.—This volume begins with a general account of the demands, uses and properties of building and ornamental stones and then after a brief geological history of the state, the different areas and quarries are taken up and described separately with an account of the rocks which they yield. A number of very excellent and lifelike (if one may use such a term in reference to a stone) colored plates of polished rock specimens have been here advantageously introduced. There are also many half-tone plates of buildings in which the various stones have been used. A large number of tests of crushing strength are given

* This Journal, III, vol. xxii, pp. 53 and 132.

and a general résumé states the best uses to which the various stones may be put. The volume shows a large amount of very careful work and is of much more than local interest and value.

L. V. P.

8. *The Cretaceous Formations of the Black Hills as indicated by the Fossil Plants;* by LESTER F. WARD, with the collaboration of Walter P. Jenney, Wm. M. Fontaine, and F. H. Knowlton (19th Annual Report of the United States Geological Survey, Pt. II, pp. 521–958, Plates LVII–CLXXII, and 3 sketch maps in text. Washington, 1899).—The foregoing paper is especially marked by a completeness of description and illustration, and a fulness of detail concerning the localities from which plants were obtained, that will materially lighten the labor of future students in this interesting field. It is a very important contribution to American paleobotany.

In the joint work, the determination of *Araucarioxylon Hoppertonæ* as one of the species in the great fossil forests of conifers occurring in the main cycad horizon is by Mr. Knowlton. The identification of plants from the Hay Creek, Wyoming, coal field is by Mr. Fontaine. A number of new species are described, but of much more importance is the recognition of some twenty-five forms also represented in the so-called Lower Cretaceous of Virginia and Maryland, particularly in the Rappahannock and Mount Vernon series of Virginia, and the Aquia Creek series of Virginia and Maryland. The contribution by Mr. Jenney deals with the geology of the Hay Creek coal field, which has evidently been worked out with much care. The remainder of the work, including the determination of plants from the Dakota group proper and the description of twenty-one new species of cycadean trunks, is by Mr. Ward.

From a morphological standpoint the greatest interest centers in the Cycads. The descriptions of these, accompanied by numerous plates, show at once the wealth and beauty of the cycadean flora of the Black Hills. In both the number of species and the completeness of their preservation this locality exceeds any hitherto reported. Bearing in mind the fact that cycadean trunks, although long known from various European Jurassic and Lower Cretaceous horizons, have been among the rarest of fossil plants, these new forms are of much importance. There is just cause for congratulation that, with the trunks procured from the Potomac formation of Maryland, it has become possible to fill up many of the gaps in our knowledge of the distribution and structure of this interesting group of Mesozoic plants.

In describing these Cycads Professor Ward has referred them all to the genus *Cycadeoidea* of Buckland, in this respect not agreeing with most English and continental botanists.

The principal results of these several studies are discussed and given in convenient tabular form at the close. It is decided that in the Black Hills rim below the Fort Benton there is a probable equivalent, at least in part, of the Dakota of Kansas and Nebraska

(Upper Cretaceous No. 1). Further, the cycad trunk horizon, which at Minnekahta is from 60 to 100 feet below this, and 175 feet above the horizon of *Barosaurus* in the Atlantosaurus Beds of Marsh, is held to be Lower Cretaceous,—probably the equivalent of the Neocomian or the Wealden. At the Black Hawk cycad locality the conditions are found to be essentially similar.

It certainly cannot be amiss to point out that we are here concerned with eighty-seven species of plants scarcely a genus of which does not have its Jurassic representative, excluding of course some half dozen plants from just below the Fort Benton, which are apparently Upper Cretaceous. In the lower portion of the strata in question, especially in the Hay Creek region, some distinctly Jurassic plants are present, and when the flora is more fully known they may prove to be more than mere "survivors," as Professor Ward suggests. As has been stated by Professor Marsh, the Cycads of Wyoming, 200 miles farther west where the faunal conditions are held to be essentially similar to those in the immediate vicinity of the Black Hills, are certainly Jurassic. Moreover, in addition to *Barosaurus* from a lower horizon, the strata on the eastern side of "the hills" contain a Dinosaurian genus closely allied to *Stegosaurus* at a distance of at least 150 feet above the marine Jurassic. Between this and the Cycads there are scarcely 100 feet of intervening strata, and no breaks are discernible. All is continuous deposition. The scantiness of knowledge regarding both the faunal and floral record, the difficulty of defining the limits of the European Jurassic, and the fact that these strata though delimited by those two great landmarks,—the marine Jurassic and Fort Benton, are all fresh water, make it clear that the physical record must also be taken into consideration. There are good reasons for believing that here exists an extensive development of distinctly fresh-water Jurassic followed by Wealden equivalents. It is not to be forgotten that farther west the corresponding strata are much thicker. Hence to state now that a Wealden or a Lower Cretaceous equivalent begins a little below the cycad horizon, or perhaps with the "quartzitic cap" just above this which still contains large fossil trees as seen in the Black Hawk locality, would mean the assuming of a difficult position. Unfortunately the conditions which in localities like the Hay Creek region were favorable for the preservation of cycadean foliage were unfavorable to the preservation of trunks, and where the latter occur the leaves appear to have been mostly destroyed. These two facts have thus far prevented our gaining a more exact knowledge of the vertical distribution of the Cycads. While Professor Ward finds ground for a final decision that the Cycads of the Black Hills are not Jurassic, in view of these elements of uncertainty their age will doubtless form the subject of further discussion. G. R. W.

9. *Les Variations périodiques des Glaciers*, 4me Rapport, 1898, rédigé par E. Richter.—This fourth Report of the International Commission on Glaciers has recently been published in

the "Archives des Sciences Physiques et Naturelles" (vol. viii, Geneva, 1899. It contains definite statements as to the recent changes in the glaciers of the Alps, with notes also on those in Scandinavia, Polar regions, Western North America, the Caucasus, Himalayas, and Central Africa. The general conclusions are most complete with respect to the Swiss glaciers. In regard to them Professor Forel remarks that measurements were made in 1898 on some 90 glaciers, 12 of which were shown to be on the increase, while 55 were certainly receding. Of the glaciers not specially observed, the great majority must be admitted to fall also in the latter class, so that we are now in a phase of very general glacial decrease. Of the Swiss glaciers which are at present advancing, several belong to the basin of the Rhone, one to that of the Aar (Rosenlauï) and one to that of the Inn (Rosegg).

In regard to the glaciers of the Eastern Alps, Prof. Finsterwalder concludes that the retrograde movement continues to gain and that the insignificant advances which were manifested in the last few years in a considerable number will probably soon come to an end. It is only rarely that any such decrease is noted as was common formerly; but frequently circles of moraines of recent date are noted, which appear to be entirely wanting in the great period of decrease between 1870 and 1890. Terminal tongues which remain stationary, or nearly so, may disappear on melting, without leaving any trace; while those which have a tolerably rapid motion forward, reform themselves in winter, producing small moraines.

Attention may also be called, in this connection, to the continuation of the paper by C. Rabot, on the variation in length of Arctic glaciers, noticed in this Journal for November, 1897, and July, 1899. The first of these papers appeared in April, 1899, and others have followed in the successive months up to and including November.

10. *On Manganese Nodules found at Onybygambah, New South Wales.*—In view of the wide-spread occurrence, in great depths of the ocean, of manganese nodules such as those observed by the Challenger and other expeditions (cf. the observations by Prof. A. Agassiz on p. 35 of this number), it is interesting to note a description of somewhat similar nodules by W. M. Doherty, as found on the Tweed River in New South Wales, Australia (Australasian Assoc. Adv. Science, vii, 1898, p. 339). He states that he found them extensively scattered over a wide area in the neighborhood of Onybygambah. They varied in size from about that of a pea to that of a Barcelona nut; they were sometimes dark and glossy on the exterior, looking like seeds, and in other cases dull black. A small part of them were perfectly spherical, but the majority, though tending towards this form, were more or less irregular. They were so soft as to be easily broken by the teeth. Three analyses gave the following results:

	Fe_2O_3, Al_2O_3	MnO_2	$MgCO_3$	Organic matter	Gangue	
1.	11·2	24·7	2·0	12·0	49·6	= 99·5
2.	8·7	25·0	2·6	12 8	50·2	= 99·3
3.	14·0	40·6	3·1	10·0	32·1	= 99·8

11. *A Treatise on Crystallography;* by W. J. Lewis, Professor of Mineralogy in the University of Cambridge. 8vo, pp. 1–612, Cambridge, 1899 (The University Press).—So many of the treatises on crystallography form merely a part of mineralogical textbooks, and hence are limited to the every-day requirements of elementary students, that the breadth of the subject might be overlooked, were it not for the occasional appearance of a thorough and exhaustive work. Such an one was presented some years ago by Professor Story-Maskelyne, and we now have another from the hand of Professor Lewis, of Cambridge.

Students of the subject not content with gaining merely such knowledge as is necessary to enable them to handle ordinary crystals, will find much to interest them and require their study in this able and profound discussion. The theoretical relations of rational indices, zone laws, symmetry, and so on, are presented with great minuteness, and then the different classes under the successive systems are taken up in succession commencing with the anorthic system (triclinic). These classes are named in part in a manner analogous to that of Groth, and in part entirely new terms are introduced. For example, under the oblique (monoclinic) system, the *gonioid* class corresponds to the domatic class of Groth (clinohedral group) and the *plinthoid* to his prismatic class (normal or holohedral group). A chapter of one hundred pages is devoted to a thorough discussion of twin crystals, first considered in general, and then with respect to occurring forms under the different systems. Another chapter takes up analytical methods, with a brief classification of other systems of notation than that of Miller, here followed; and the work closes with an account of different forms of goniometers.

12. *Praktische Anleitung zur Analyse der Silikatgesteine nach den methoden der Geologischen Landesanstalt der Vereinigten Staaten* von Dr. W. F. Hillebrand. Nebst einer Einleitung enthaltend einige Prinzipien der petrographisch-chemischen Forschung von F. W. Clarke und W. F. Hillebrand. Uebersetzt von Dr. E. Zschimmer; pp. 86. Leipzig, 1899 (W. Engelmann.)—This useful volume is essentially a German reproduction, with some changes chiefly of arrangement, of the general portion of Bulletin No. 148 (1897) of the U. S. Geological Survey. The excellent analytical work carried on in the laboratory of the Survey under the charge of Prof. Clarke, largely by Dr. W. F. Hillebrand, has contributed much to our knowledge not only of the composition of minerals and rocks, but also of the best methods of analysis. It is gratifying, therefore, that this excellent treatise should be put in a form to command a still wider circle of readers.

13. *Darstellung der 32 möglichen Krystallklassen auf Grund der Deck- und Spiegelachsen nebst Beschreibung von Achsenmodellen*

zur Demonstration der Symmetrieverhältnisse der Krystalle von H. BAUMHAUER; pp. 36, 1 plate. Leipzig, 1899 (W. Engelmann).—The author takes up in the present work the thirty-two classes of crystals, arranged according to their symmetry, and develops the relations between them with much clearness and sharpness. Since fourteen of the classes have no plane of symmetry and twenty-one have no center of symmetry, he prefers to base the fundamental relations upon the axes of symmetry. Of these he distinguishes between two types, the "Deckachsen" and the "Spiegelachsen," the latter being the axes of composite symmetry; these are further defined as "homogene" or "inhomogene," etc. The two classes of the triclinic system fall into an *anaxial* division, and the remaining thirty into the *axial* division; the latter are subdivided into the *monogonal, digonal, tetragonal* groups, etc.

III. BOTANY.

1. *How are seeds affected by a temperature of −250° C.?*—Sir W. Thiselton-Dyer gives in the Proceedings of the Royal Society (vol. lxv) a very interesting account of his experiments with seeds under the influence of liquid hydrogen. They are especially instructive when taken in connection with the experiments by Messrs. Browne and Escombe. We give a few extracts from Sir William's paper.

"When Professor Dewar first suggested the experiment to me, he pointed out that it would be a costly one, that it would only be possible to operate on very small quantities of seeds, and that the number of kinds must also be few.

The dozen seeds experimented upon by Messrs. Browne and Escombe, which were submitted to the temperature of liquid air, were apparently selected as belonging to different natural families, and also in some degree as to their composition.* My choice was much more restricted. I took two out of their list for the sake of comparison: barley and vegetable marrow. I added wheat, which had more than once been made the subject of experiment. This gave me two farinaceous seeds and one oily one. I then took shape and bulk into account. Wheat and barley are roughly ellipsoidal and medium in size. The vegetable marrow is relatively large but flattened. I therefore added another oily seed, mustard, which is small and spherical. I followed Messrs. Browne and Escombe in taking a pea, which is also spherical in shape but nitrogenous in composition. Finally I sought a very minute seed, and pitched upon musk.

The list then ultimately stood:

Brassica alba.
Pisum sativum.
Cucurbita Pepo.
Mimulus moschatus.
Triticum sativum.
Hordeum vulgare.

* Roy. Soc. Proc., vol. lvii, p. 161.

The next point seemed to be to eliminate the source of error which might arise from defective germinative power. I therefore communicated the list to Messrs. Sutton & Sons, of Reading, and asked their assistance. With their invariable kindness in any scientific enquiry, they willingly complied, and sent the samples required with the following report:

'We now have pleasure in sending a packet of each of the seeds you name. They are all of last year's growth, and of good germination. For your information we append the germinations arrived at by our tests made in March last of the various parcels from which these samples are taken. We have no doubt that each grain of wheat is a germinating seed, as specially fine seeds have been picked out. In the case of musk a good growth was obtained, but the germination was not counted.

'Germinations:

Mustard	100 per cent.
'Bountiful' peas	100 "
Vegetable marrow	96 "
Musk	Good.
Wheat	96 "
Barley	100 "

I forwarded the samples (which were small) to Professor Dewar, and suggested that they should be each divided into two portions, one for a control experiment under ordinary conditions, the other to be returned to me after being subjected to cooling. Owing to some misunderstanding, this was not done; but, as will be seen in the result, the omission proved immaterial. The seeds, it should be stated, were simply air-dried: they were ordinary commercial samples, and no attempt was made to further desiccate them. . . . . .

On July 21 he wrote to me:—'In spite of the weather I have carried out my promise, and cooled some seeds in liquid hydrogen for half an hour. I had to seal them up in a glass tube, cool first in liquid air, and then transfer to the hydrogen. They have, therefore, been cooled to −250° C., or −252° C., while being in a vacuum (seeing the air left had no appreciable tension). The seeds in other words, have been transferred to a condition resembling that of moving through space. Another set of the seeds have been cooled only in liquid air for comparison.'

On July 22 he added, on returning the seeds:—'There can be no doubt about the seeds being cooled, as they were in the hydrogen for more than an hour. In fact I used nearly 600^{cc} of liquid hydrogen.'

The seeds came to me in the small packets of tinfoil in which they had been placed in the tube. On opening these it was observed that the seeds were as fresh and bright as before being subjected to the treatment. There was not the slightest dis-

coloration observable in the green tint of the peas. This practically disposed of the only anxiety which Professor Dewar felt as to the success of the experiment, and expressed to me on July 25:—

'My own impression is that unless the sudden vacuum caused by the liquid hydrogen cooling has produced physical rupture of the seeds, they will germinate as usual. If they survive this awful strain, then I believe no increase of the time of cooling could produce any effect other than results from one hour's exposure to such severe cold.'

The seeds were sown in a cool greenhouse, without heat, on July 27. On August 1 they had all germinated. In the case of the mustard, 136 young plants were produced from 155 seeds; the remainder had, however, germinated, but the seedlings had damped off. One of the packets of wheat, for some reason, germinated slightly more slowly than the rest.

On August 5, I received a further packet of the seeds (the musk excepted, indiscriminately mixed. Professor Dewar wrote the same date:—'I have sent you seeds to-day which, if the treatment with cold can kill, ought to be dead. They have been immersed in liquid hydrogen for upwards of six hours, and no attempt was made to graduate the cooling. They were placed in the vacuum vessel into which the liquid hydrogen could drop from the apparatus, and had to take their chance. The seeds have been soaked in liquid hydrogen, and in this respect differ from the last that were cooled in a vacuum from being sealed in a glass tube.'

In this instance again the seeds did not show the smallest visible trace of the ordeal to which they had been subjected. They were sorted out and immediately sown, under the same conditions as before. By August 9 the seeds had all germinated without exception. I communicated the result to Professor Dewar, and he informed me, August 15:—'The temperature Fahrenheit to which the seeds were cooled was —453° F. below melting ice.'

These are the details of the experiment. As it is not likely to be often repeated, I have thought it worth while to place them on record as precisely as possible.

The first question that suggests itself is, what evidence we have for believing that the seeds have actually been brought to the almost inconceivable temperature with which they were surrounded. That they were so brought, Professor Dewar himself has not a shadow of doubt. That substances at widely extreme temperatures can remain in juxtaposition at least for some time, and still maintain them, is illustrated by a striking experiment shown by Professor Dewar at the Royal Institution on April 1, 1898. Liquid air poured into a large silver basin heated to redness remained apparently as quiescent at this high temperature as in cooler vessels, and maintained a spheroidal condition. This is well understood. But the fact remains that liquid air with a temperature of about —190° C. was contained in a vessel which

had a temperature of 800° C., the difference in temperature between the two being 1000° C. . . .

It is probable that plant structures are deficient in thermal transparency, and they are notoriously indifferent conductors. Nevertheless it is difficult to believe that in the case of such small bodies as seeds, their being brought to the temperature with which they are surrounded can be more than a question of time.

That the thermal opacity of at least the seed-coats, may be really considerable is not, however, impossible, even at low temperatures. The following remarks by Professor Dewar have an obvious bearing on this point :—

'Pictet, after an elaborate investigation, concluded that below a certain temperature all substances had practically the same thermal transparency, and that a non-conducting body became ineffective at low temperatures in shielding a vessel from the influx of heat. Experiments, however, prove that such is not the case, the transference of heat observed by Pictet appearing to be due, not so much to the materials themselves, as to the air contained in their interstices. Good exhaustion in the ordinary vacuum vessels used in low temperature work, reduces the influx of heat to one-fifth of what is conveyed when the annular space of such double-walled vessels is filled with air.'*

It is to be noticed that in Professor Dewar's first experiment the seeds were practically in a vacuum. It is obvious from what has been quoted above, that this would help them to retain their heat. Any hesitation in accepting the results of the experiment on this ground is, however, swept away by the second experiment, in which the seeds, with absolutely no protection at all, were actually soaked in liquid hydrogen for six hours. The extremity of caution can hardly resist the conclusion that they must have been brought to the same temperature.

Professor Dewar finds 'that silica, charcoal, lampblack, and oxide of bismuth, all increase the insulation to four, five and six times that of the empty vacuum space.' It might possibly be worth while to try how far a packing of small air-dry seeds would compare, say with charcoal. And this would in some degree be a measure of the thermal transparency of seed structures."

2. *Praxis und Theorie der Zellen- und Befruchtungslehre ;* von Dr. V. Häcker (Freiburg i. Br.) Jena, Gustav Fischer, 1899.

Fixirung, Färbung, und Bau des Protoplasmas ; von Dr. A. Fischer (Leipzig), Jena, Gustav Fischer, 1899.—We have brought these two books together under observation in the present notice, as interesting examples of the exhaustive character of the work which is now going on in that department of investigation which deals with the cell. These studies sweep through the whole range from the suggestive resemblances to organized substances which are found in or can be produced in

* "On Liquid Air as an Analytic Agent," Roy. Inst, April 1, 1898, pp. 7 and 8.

inorganic things, up to the complex factors which are concerned in reproduction of animals and plants. The technique in both these works is precise and special, with explicit directions for procedure which can hardly be misunderstood. The feature which strikes one most forcibly in looking through these excellent handbooks is the entire absence, in the choice of illustrations, of any barrier between the two kingdoms of animals and plants. The recent interesting artificial production of extra-nuclear karyokinetic figures by the employment of certain reagents such as albumose and osmic acid, and the singular imitations of a few of the characteristics of protoplasm, are here presented in almost their latest form, and excite keen curiosity as to the possibilities in this new department of microscopic research. The handbooks are well arranged and are convenient for reference: the indexes being full and useful. G. L. G.

3. *Untersuchungen ueber die Vermehrung der Laubmoose durch Brutorgane und Stechlinge;* by Dr. CARL CORRENS. 1899, Jena. Gustav Fischer; 472 pp., 8°, 187 figures.—In this elaborate monograph, dedicated to the memory of Naegeli by his last pupil, the author gives the results of his histological studies on the non-sexual methods of reproduction in mosses. The number of species studied was so large that the work may be regarded as an encyclopædia of the subject. The author, contrary to the generally received opinion that any cell of a Brutorgan is capable of developing into a vegetative shoot, believes that this capacity is limited to certain cells which he calls Initial-cells. The separation of a Brutorgan is accomplished in two different ways. In the first, or schizolytic, method the rupture is along the middle lamella; in the second, or rhexolytic method, the cells themselves are ruptured and, in the more complicated Brutorgane, certain definitely arranged cells are destined to be ruptured. The author's observations confirm the view that Brutorgane, representing non-sexual growths, are correlated with the sexual, or capsular, growths, so that where the former are abundant the latter are scantily developed or wanting, but he expresses the opinion that the capacity for producing Brutorgane is inherent and is independent of any other property of the species. W. G. F.

4. *Analecta Algologica, continuatio V;* by Professor J. G. AGARDH. Acta. Reg. Soc. Physiogr. Lund, x, pp. 160, 4°, pl. i–iii.—This continuation of the Analecta, with the exception of a short chapter on the new Australian genus of Fucaceæ, *Scænophora*, treats entirely of Florideæ. There is a revision of the subgenera of the genus Gigartina, with notes on certain species including eleven species from our Pacific Coast, and revisions of species formerly placed in Halymenia and Chrysymenia, from which several new genera are formed. The new genus Collinsia with a single species from California is related to Grateloupia. There is, however, already a genus of phænogams called Collinsia. Among other new American species are *Calosiphona caribæa*, *Dudresnaya canescens*, *Helminthopsis verticillifera* and *Naccaria*

corymbosa from Florida and the West Indies, and *Helminthocladia Batrachopus*, *Meredithia Californica* and *Pyropia Californica* from the West Coast. W. G. F.

5. *The Teaching Botanist: a Manual of Information upon Botanical Instruction, together with Outlines and Directions for a Comprehensive Elementary Course;* by WILLIAM F. GANONG, Ph.D., Professor of Botany in Smith College; pp. xi + 270, with 29 figures in text. New York, 1899 (The Macmillan Company).—Professor Ganong's book occupies a unique field among botanical text-books and is addressed to teachers of botany rather than to their pupils. It is full of the most helpful directions and suggestions and sets forth clearly the aims of modern botanical teaching. The first part is taken up with eight "essays on botanical pedagogics," and the following are among the topics discussed: things essential to good botanical teaching, botanical laboratories, collections and books, scientific drawing and description, common botanical errors. In the second part, an elementary course in botany is described, which is arranged with reference to the principles emphasized in the first part. The topics are carefully selected, so as to illustrate clearly and connectedly the "most vital and illuminating" facts of botany and at the same time to draw out "most quickly and thoroughly" the student's faculties. The essentials of anatomy, morphology, physiology and ecology are taught from flowering plants, as it is deemed advisable to begin with objects more or less familiar to the student, and the course is concluded with a short and general survey of the vegetable kingdom, beginning with the Algæ and ending with the angiosperms. The book is particularly welcome at the present time when the teaching of botany is in a somewhat unsettled state. It is to be recommended not only to teachers of the science but also to those persons who still consider the study of botany as synonymous with the analysis of flowers. A. W. E.

6. *Lectures on the Evolution of Plants;* by DOUGLAS HOUGHTON CAMPBELL, Ph.D., Professor of Botany in the Leland Stanford Junior University; pp. viii + 319, with 60 figures in text. New York, 1899 (The Macmillan Company).—The science of evolution has so often been treated from a zoological standpoint that its principles are fairly well understood. The present account, however, although taken up with topics more or less familiar to the botanist, fills a gap in biological literature, by presenting the subject of plant evolution in a clear and connected manner. The two introductory chapters describe briefly the important facts in regard to the anatomy and physiology of plants and the external conditions under which they grow. The study of plant evolution then begins with a discussion of the "simplest forms of life," including the slime-molds, the bacteria, the Cyanophyceæ and certain of the unicellular green Algæ. This is followed by chapters on the other Algæ, the Fungi, the bryophytes, the pteridophytes, the gymnosperms and the two classes of angiosperms. At all points the interrelationships of the types selected are emphasized,

and the text is frequently elucidated by diagrams representing lines of descent. The author then discusses the geological and geographical distribution of plants, the interdependence between animals and plants, and the effect of environment upon plant-life. Professor Campbell's original work upon the archegoniates and the lower monocotyledonous plants has particularly fitted him for writing a book of this character. A. W. E.

7. *Botanizing: a Guide to Field-Collecting and Herbarium Work;* by WILLIAM WHITMAN BAILEY, A.M., Professor of Botany in Brown University; pp. ix+142, with frontispiece and 15 figures in text. Providence, R. I., 1899 (Preston & Rounds Company).—The Botanical Collector's Handbook, published by Professor Bailey nearly twenty years ago, is well known to botanists and will give an idea of the matters treated in the above work. The new book, however, is entirely rewritten and has incorporated in it many new and important observations and directions. In discussing the collection and preservation of the willows, the mosses, the Algæ and the Fungi, the author has engaged the help of specialists. A. W. E.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *The Life of James Dwight Dana, Scientific Explorer, Mineralogist, Geologist, Zoologist, Professor in Yale University;* by DANIEL C. GILMAN, pp. 1–409. New York, 1899 (Harper Brothers).—In this biography, which the author describes as "personal rather than scientific," an admirable sketch is given of both the personality and work of one who for a full half-century was a central figure in the development of Natural History in North America. Had he not left the impress of his life upon the very details of the several sciences he advanced, such a brief sketch would be far from satisfactory. Brief as it is, one catches from its reading the inspiration of the busy life and is overwhelmed with the prodigious amount of work accomplished in a single lifetime.

The author has performed his part with great skill, adding to his wide knowledge of science a keen appreciation of the personal characteristics of Professor Dana, with whom few of those who survive him (due to his delicate health) had the privilege of intimate acquaintance.

A single sentence in a letter to Guyot, written two days after his fifty-second birthday, vividly expresses the noble spirit of his life. "I feel anxious to work, and work effectually, while the day lasts, having a constantly augmenting realization of the greatness and extent of the work to be done to keep science headed aright in these times." (p. 330.) W.

2. *November Meteors of 1899.*—Further reports confirm the comparatively slight character of the Leonid shower this year. The maximum density seems to have occurred on the night of November 14–15, when it was clear in Canada and neighboring

regions, and a considerable display was observed at Montreal. Rev. Joel H. Metcalf reports that at Burlington, Vermont, 93 Leonids were seen by his party on that night between 1 A. M. and dawn, and he was successful in securing one or two meteor-trails by photography. Our knowledge of the distribution of the bodies forming the stream is likely to grow very slowly, as, if the period is 33¼ years, we shall not encounter this part of the stream again until the year 2032.

Quite a display of Andromedids was observed on the nights of November 23 to 25, Professor Young of Princeton, New Jersey, having seen, according to press reports, as many as 10 per minute on the latter night for a short period. At New Haven it was clear on November 23 and 24 and on the latter night a number of trails were photographed, one of which was secured at both of the Observatory stations and will thus afford a determination of its position, direction, and velocity. W. L. E.

3. *The Aims and Methods of Meteorological Work especially as conducted by National and State Weather Services;* by CLEVELAND ABBE.—This interesting paper is reprinted from Part III (pp. 219–330) of the Report on the Meteorology of Maryland, prepared by Cleveland Abbe, O. L. Fassig, and F. J. Walz by direction of Willis L. Moore, Chief of the U. S. Weather Bureau.

The Maryland Weather Service is under the directorship of Prof. W. B. Clark, whose excellent work on the Geology of Maryland has already resulted in the production of the valuable and handsome volumes before noticed in this Journal. The present paper is a popular survey of the entire subject of meteorological work, especially in its application to the State of Maryland. The principles involved in the prediction of storms, wind, frost, fog and other important weather conditions, are explained very clearly. Then the various elements involved in climatology are explained, and finally the special apparatus and methods employed in observations of temperature, wind, velocity, atmospheric pressure, etc. The whole forms an admirable chapter for the instruction of that large part of the public which, though interested, has little definite information in this direction and is too slow to recognize the high standard and constantly progressive character of the work done by our Weather Bureau. It is profusely illustrated with excellent plates and published in the same liberal way as the other volumes from the same source.

4. *Our Native Birds:* How to protect them and attract them to our Homes; by D. LANGE; pp. 1–162, 12mo. New York, 1899 (The Macmillan Company).—This attractive little book is especially designed to aid in the most laudable effort to protect our native birds, particularly by those means which cannot be made matters of legal requirement. The author calls attention to the fact that though it is easy to pass laws against recognized evils, it is much more difficult to provide means for enforcing their provisions. Hence the suggestions which he makes here are most valuable, and it is to be desired that they should find wide adoption.

5. *The Elements of Blowpipe Analysis;* by FREDERICK HUTTON GETMAN, Instructor of Chemistry in the Stamford High School; pp. 77, 12mo. New York, 1899 (The Macmillan Co.).—This little book contains a brief outline of the methods of blowpipe analysis, and a statement of the general reactions of prominent substances and compounds; also a description of the most common ores of the different metals, with full statement of their blowpipe characters. It will be found useful by those who do not desire to use one of the large and detailed manuals.

OBITUARY.

SIR JOHN WILLIAM DAWSON.

It is with deep regret that we record the death of Sir William Dawson, which took place at Montreal on November 19th in the 79th year of his age. By his death Canada loses a distinguished geologist as well as one who was intimately identified with educational work of all kinds, but more especially with higher education, in the Province of Quebec.

He was born at Pictou, Nova Scotia, on October 13th, 1820, his father being a shipbuilder in that town, and studied at Pictou College and subsequently at the University of Edinburgh, under Jameson, Forbes and Balfour. He returned to Nova Scotia in 1847 and three years later, having already attracted some attention by the publication of a number of papers, reports and lectures, he was appointed Superintendent of Education for that Province. His work in connection with this position obliged him to travel continually through all parts of Nova Scotia, and on these journeys he accumulated the materials for his largest work, that entitled "Acadian Geology." While carrying on this work he met Sir Charles Lyell, with whom he studied the now celebrated Joggin's Section on the Bay of Fundy.

In 1855 Sir William was appointed to the Principalship of McGill University, a position which he held until 1893. He was at the same time Professor of Geology, and the University prospered under his management beyond the most sanguine expectations of its friends. In addition to administering the affairs of the University and delivering several courses of lectures every year, he was first and foremost in every movement to further education and also found time to carry on original work along several lines, achieving very valuable results. He was also the author of many popular books on scientific subjects, more especially in connection with geological science.

In 1883 he traveled extensively in Egypt and Syria, studying the geology of these countries and its relation to sacred history.

He took an active part in the organization and proceedings of the meeting of the British Association for the Advancement of Science, held in Montreal on the following year, on the occasion of which he received the honor of knighthood.

In 1893 Sir William was seized with a very severe attack of pneumonia and his health became so seriously impaired that he was obliged to give up work for a time and spend the winter in the south. His strength, however, was not restored, and he resigned his position as Principal of McGill University in 1894. During the later years of his life his strength gradually ebbed away and what little work he could undertake consisted in arranging his collections and working up some unfinished papers. Several of these were published in 1894 and 1895, but the years of quiet labor to which he looked forward at this time, were cut short by a series of sharp attacks culminating in partial paralysis, which forbade further effort. He passed away on the 19th of November very peacefully and without pain.

Lady Dawson, with three sons and two daughters, survive him. His eldest son, Dr. George M. Dawson, the present Director of the Geological Survey of Canada, has inherited his father's love for geological work and has achieved wide distinction in the world of science.

Sir William's first original contribution was a paper read before the Wernerian Society of Edinburgh in 1841 on a species of field mouse found in Nova Scotia. From that time onwards he was a continuous contributor to scientific journals and to the publications of learned societies.

The most important work of his earlier years was an extended study of the geology of the eastern Maritime Provinces of Canada, the results of which are embodied in his "Acadian Geology" already mentioned, a volume of nearly 1000 pages accompanied by a colored geological map of Nova Scotia, and which has passed through four editions. He subsequently devoted much time to various researches in palæobotany, more especially in connection with the Upper Silurian, Devonian and Carboniferous systems of eastern Canada and of the Cretaceous and Tertiary of the western portion of the Dominion. The results of these researches were published in a long series of papers which appeared chiefly in the Quarterly Journal of the Geological Society and in the Transactions of the Royal Society of Canada. He also contributed a volume entitled "The Geological History of Plants" to Appleton's International Scientific Series.

In 1863 he published his "Air Breathers of the Coal Period," which contained the results of many years study of the fossil batrachians and land animals of the Coal Measures of Nova Scotia, the earliest known remains of Microsauria having been discovered by him in the interior of decayed tree stumps in the Coal Measures of South Joggins. The results of his later studies of these creatures were embodied in a series of subsequent papers

Sir William also while residing in Montreal, devoted much at-

tention to the Pleistocene deposits in the vicinity of the city and in fact to those of eastern Canada generally, especially to the remarkably rich invertebrate fauna which they contain. His "Canadian Ice Age" embodies the chief results of this work and is one of the most important contributions to the palæontology of the Pleistocene in America, which has hitherto appeared.

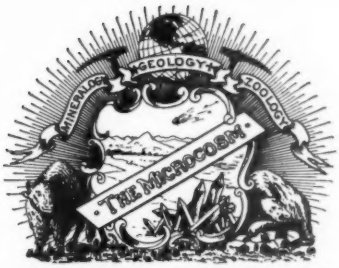
His work in connection with Eozoon Canadense is well known. Sir William was also a prolific writer of popular works on various geological subjects. Among these may be mentioned his "Story of the Earth and Man," his "Fossil Men and their Modern Representatives," his "Meeting Place of Geology and History," and many others. These books, written in a very entertaining style, had a wide circle of readers. Many of these volumes as well as many papers contributed to various religious papers treated of the relation of science and religion. He was a Presbyterian of the old school and strongly opposed to all theories of the evolution of man from brute ancestors, nor would he allow anything more than a very moderate antiquity for the species. The study of geology, too, he would have emancipated from "materialistic infidelity which, by robbing nature of the spiritual element and of its presiding Divinity, makes science dry, barren and repulsive and diminishes its educational value."

These works on the relation of science and religion, while they undoubtedly met a popular demand, have but a transitory value and are not those by which Sir William Dawson will be remembered. His reputation will rest on his great contributions to our permanent stock of knowledge, representing achievements of which any man might well be proud.

His name has been perpetuated in connection with the geological work of McGill University by the erection of a second chair in geology to be known as the Dawson Chair, which has just been endowed by Sir William Macdonald.

Sir William was a man of quiet geniality, gentle and even deferential in manner, but decided in opinion and firm in action. The preëminent note of his character was sincerity and singleness of purpose. His loss will be felt by all who knew him, but especially by the members of the University with which he was so long connected. FRANK D. ADAMS.

Dr. Henry Hicks, the English geologist, best known for his able investigations of the pre-Cambrian rocks of Wales and Scotland, died on November 18th, at the age of sixty-two years.



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(1) Described in this Journal Sept., 1895. (2) Ibid Nov., 1887. (3) Proc. Roch. Acad. Sci. Vol. I. (4) This Journal Aug., 1888. (5) Ibid July, 1893. (6) Ibid June, 1894. (7) Ibid Nov., 1892.

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